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DC-8, AIRBORNE LABORATORY
EXPERIMENTER HANDBOOK**

CHAPTER 4

FUSELAGE VIEWPORTS AND WINDOWS

1. General Information

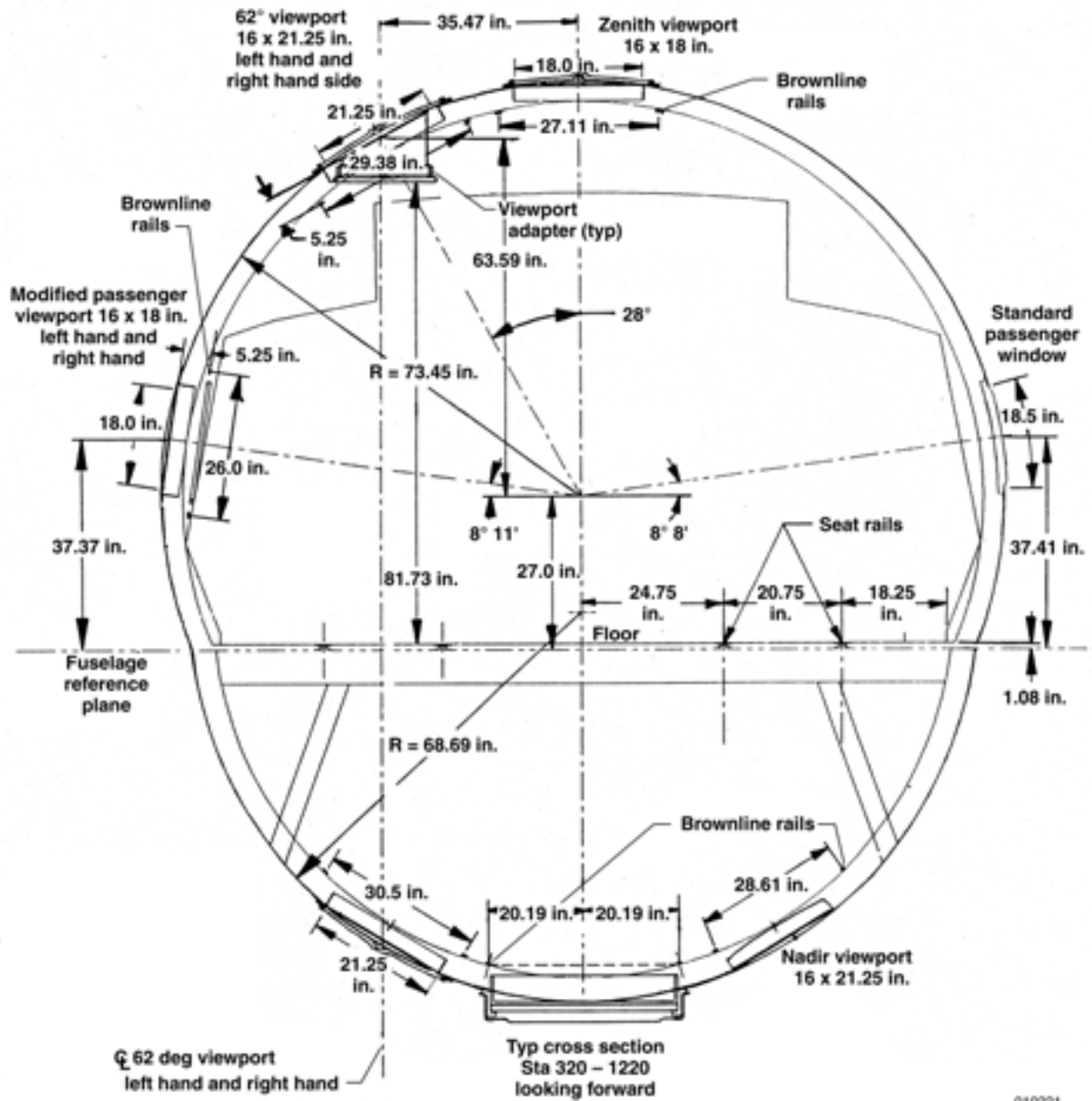
An assortment of special viewports, accommodating up to 16 in. (0.41 m) diameter clear aperture windows, have been installed in the fuselage at various elevations and longitudinal locations. In addition, several of the standard passenger windows have been modified for special viewport uses (see chapter 3, figure 3-1). These special viewports and windows can be used for optical viewing; therefore, they have been equipped with defogging systems and appropriate safety features that permit the use of various transparent materials. The ports will also accommodate aluminum plates that can be used to support external gas sample probes, small antennas, radiometers, and other lightweight units that require fuselage penetration.

Unmodified passenger windows are on occasion used for optical viewing when surface and transmission quality are acceptable. For example, film and video cameras can document surface or cloud information to support other instruments.

2. General Description

Viewports and windows in the cabin area are identified by their angle of elevation within the fuselage. There is one zenith (90°) viewport on the aircraft centerline, four 62° upward-looking viewports (three left and one right hand side), and ten passenger windows modified to be 8° viewports (six left and four right hand side). In addition, there are four nadir ports (downward looking). They are located in the fore and aft cargo compartments with one port in each cargo compartment on the aircraft centerline, and two smaller ports (both left and right hand side) in the aft cargo compartment positioned directly beneath 62° overhead viewports. There are hatches in the cabin floor aligned with these upper and lower ports so that an instrument may view up and down the vertical axis simultaneously. The zenith, 62°, and nadir viewports are equipped with external sliding shutters that can be opened and closed in flight. These shutters are to protect the external surfaces of the optical windows on the ground, and during takeoff and landing.

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Figure 4-1. Viewport information.

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Table 4-1. Location, aperture size, and load capacity of viewports.

Viewport	Approximate Location on Centerline	Size¹, in.	Number of Hardpoints²	See Figure:	Capacity³ lb @ in.
Zenith, Nadir, and 62 ° Ports:					
Zenith no. 1	Sta. 330 C/L	16 x 18.0	4	4-4	100 @ 10
Nadir no. 2	Sta. 420 C/L	37.25 x 30.0	6	4-5	250 @ 24
Nadir no. 7	Sta. 1200 C/L	37.25 x 30.0	6	4-5	250 @ 24
62 ° no. 1	Sta. 470 LH	16 x 21.25	4	4-2	100 @ 10
62 ° no. 3	Sta. 1090 LH	16 x 21.25	4	4-2	100 @ 10
62 ° no. 4	Sta. 1130 LH	16 x 21.25	4	4-2	100 @ 10
Nadir no. 5	Sta. 1130 LH	16 x 21.25	4	4-2	150 @ 15
62 ° no. 8	Sta. 1310 RH	16 x 21.25	4	4-2	100 @ 10
Nadir no. 9	Sta. 1310 RH	16 x 21.25	4	4-2	150 @ 15
Camera Ports:					
Nadir no. 1	Sta. 300	5 x 3	0	-	-
45 °	Sta. 330 LH	3 dia.	0	-	-
Modified 8 deg Passenger Window Ports:					
8 °	Sta. 330 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 450 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 530 RH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 570 L&R	16 x 18	4	4-3	100 @ 10
8 °	Sta. 890 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 1010 L&R	16 x 18	4	4-3	100 @ 10
8 °	Sta. 1290 L&R	16 x 18	4	4-3	100 @ 10

¹. Longitudinal (fore/aft) dimension appears first.

². Minimum number required for experiment.

³. Total, perpendicular to the plane of the hardpoints.

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3. Configuration Details

The location, aperture size, and load capacity of the viewports are given in figure 4-1 and table 4-1, while the detailed dimensions of frames and the immediate surroundings are given in figures 4-2, 4-3, 4-4, 4-5, and 4-6.

Figure 4-6(a) and (b) give the specifications of the viewports, size of the glass (and other selected materials), and the corresponding inner frame and the seal arrangements. Figure 4-7 gives the size and panel thickness of the standard passenger windows.

A variety of techniques are available for mounting optical windows in the fuselage viewports. Two representative samples are shown in figure 4-6(a) and 4-6(b). Figure 4-6(a) illustrates a 7.0-in. (17.8 cm) diameter window installed in an 8-deg (modified passenger) viewport, while figure 4-6(b) illustrates a 16-in. (40.6 cm) diameter window installed in a 62° viewport. In each example, the bare glass (or optical material) is surrounded by a cushion of silicon rubber gaskets, and then by a metal casing ring or plate, which protects the window during handling. This casing also allows the window to be mounted to an appropriate adapter, which in turn fits the viewport of the aircraft.

All optical viewports have internal sliding safety shields, to provide pressure safety and to protect the inner surfaces of the optical windows. Normally, the shields are closed when the viewport is not being used and during takeoffs and landings. Experiment installations should be designed to clear the safety shields. The shields may be refitted to accommodate an experiment, if justified by special requirements. Advance request of at least three months is required, to allow for approval, design, and fabrication.

4. Special Inserts

A special adapter is provided for 62° and nadir viewports, to position the optical window parallel to the cabin floor and permit viewing normal to the window surface (see figure 4-2). At any viewport, an approved metal plate sized to frame dimensions, may be used to mount an instrument or antenna (see figure 4-8). The load that these inserts can support without attachment to window hardpoints is limited. Each installation is considered individually and must be discussed with the DC-8 mission manager during the preliminary planning. Correspondingly, when hardpoints are used to support equipment that extends through the metal viewport insert (such as a blade antenna), the unique loading and sealing requirements must be treated as a special case.

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5. Optical Windows

Numerous experimenters on the DC-8 have utilized optical (quality) windows. There is a limited stock of these windows, in various materials, held in secured storage. DFRC maintains a program of pressure/thermal testing and refurbishment, to meet aircraft safety requirements. Each optical window (or spare), from whatever source that will fly on the DC-8, must be inspected, tested, and approved as airworthy at DFRC test facilities prior to installation. Optical data files are maintained for these windows; the data includes transmittance, reflectance, flatness, and condition of surface or coating.

If an appropriate window is not available from stock, the experimenter must provide one. Either DFRC or the experimenter may supply the frames and the port inserts to accommodate the window materials.

Adapter plates must be used for all circular optical materials in order to adapt them to the standard rectangular shape of the aircraft window.

Special window requirements should be requested as early as possible, to allow for design, fabrication, and testing. Lead time to acquire finished optical materials can be six months or more, depending on composition and size.

A. Window Materials

Stock full-aperture, 16 in. (40.6 cm) diameter, window materials include borosilicate crown glass (BK-7), and UV grade fused silica. There are also a variety of other optical materials, all less than full aperture in size, such as high-density polyethylene, IrTran, germanium, and Pyrex.

As a guide to the design of special-purpose windows, table 4-2 lists representative materials, sizes, and minimum allowable thickness. Note that circular shapes are strongly preferred due to lower stress levels. All edges of glass-type materials must be chamfered (figure 4-6) and scratches, digs, or un-smoothed edge chips may disqualify a window for use. It is mandatory that any window material be isolated from metal inserts or frames by silicone rubber gaskets (grade 40), with sufficient tolerance to prevent strain from thermal and mechanical effects. The optical characteristics of the standard unmodified passenger windows (figure 4-7) are given in figure 4-9.

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B. Environmental Testing of Optical Windows

Each window assembly, complete with frame and gaskets, is tested at DFRC prior to installation aboard the aircraft. To allow adequate time for testing, window parts must be at DFRC a minimum of four weeks prior to the scheduled installation. Each window must be marked to identify the cabin side before tests begin.

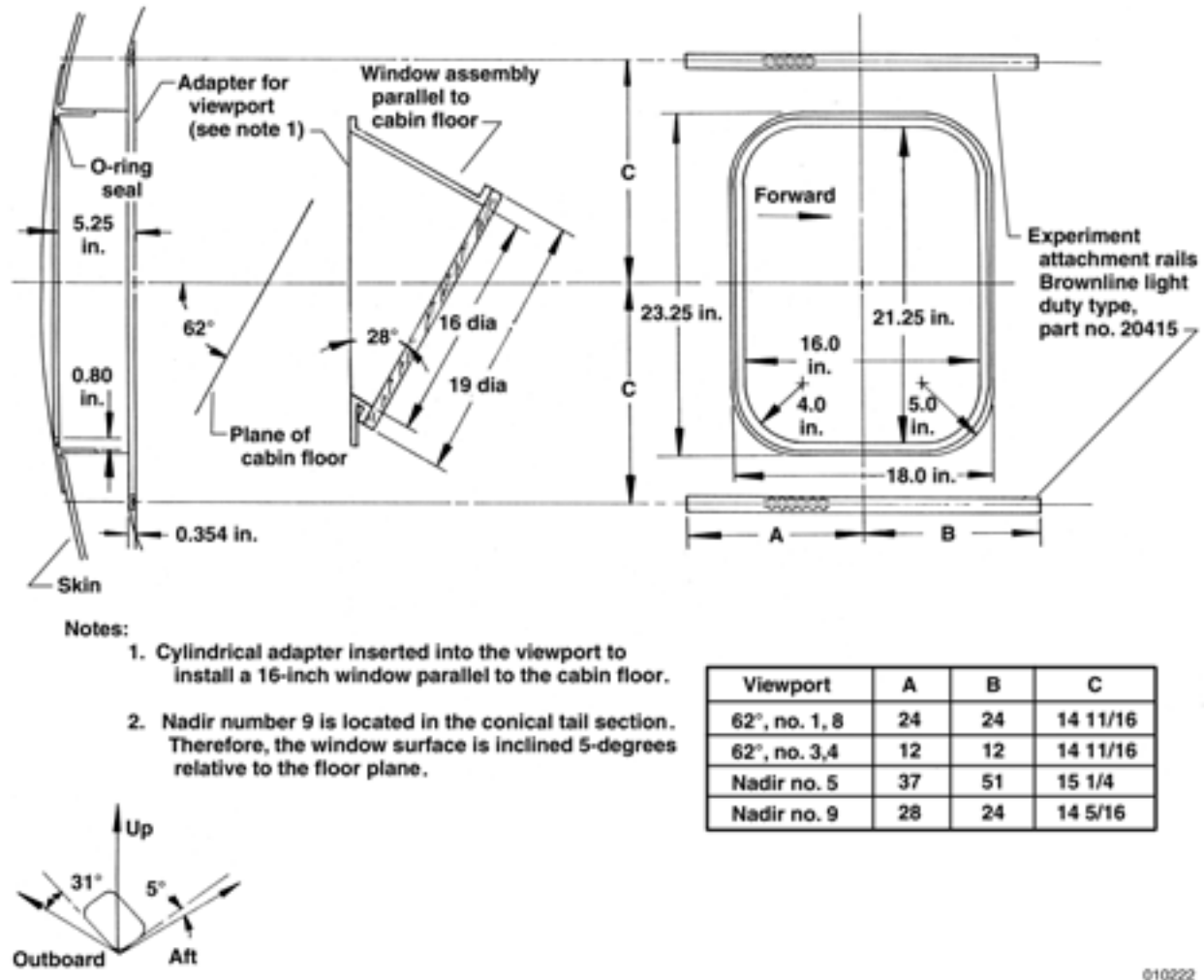
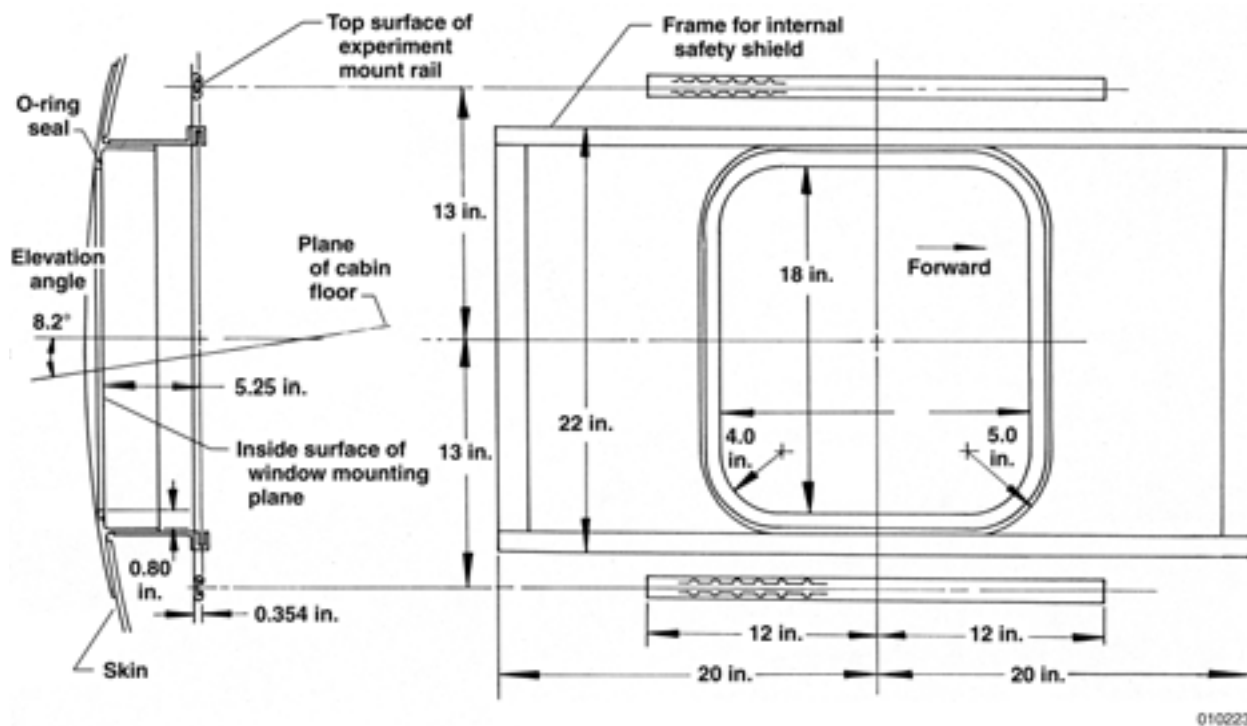


Figure 4-2. Typical 62° viewports and nadir 5 and 9.

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Figure 4-3. Typical 8° viewport.

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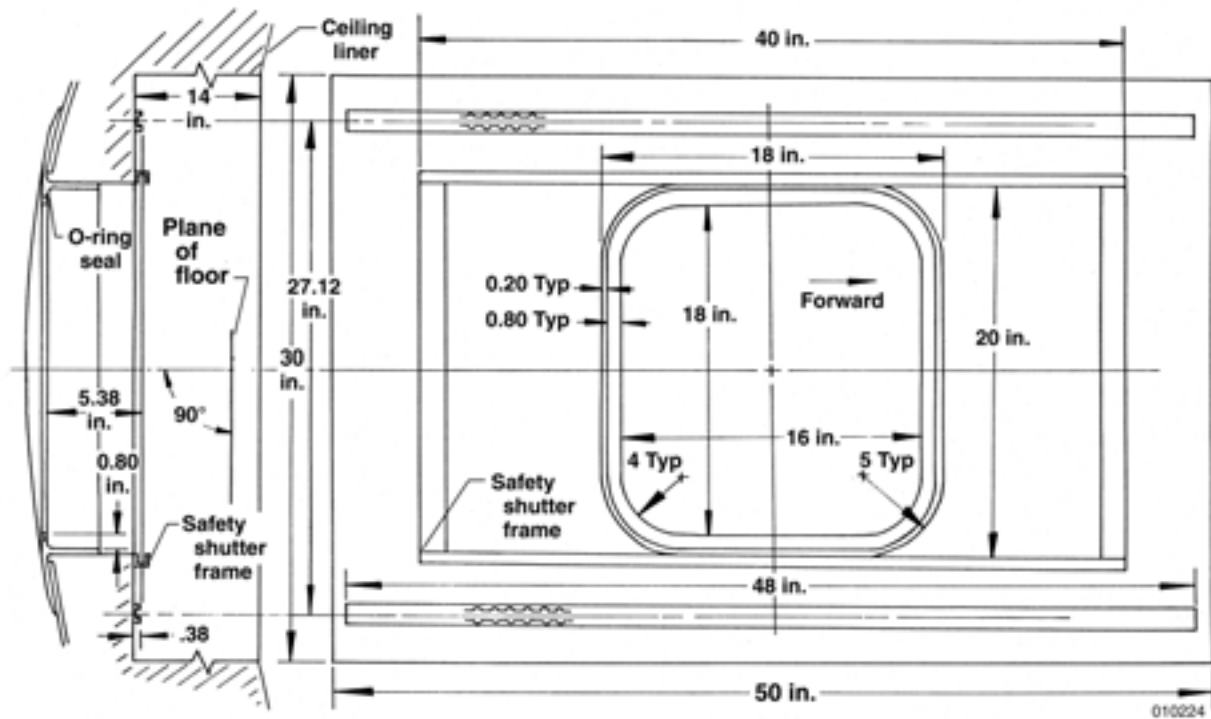


Figure 4-4. Typical zenith viewport.

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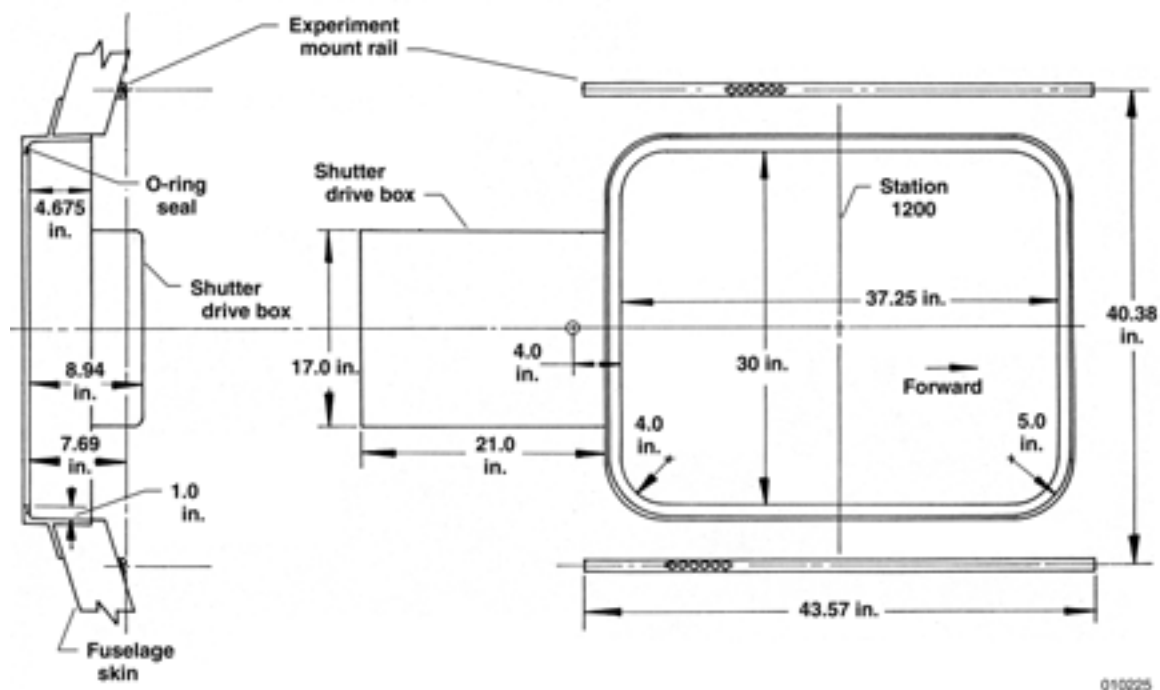


Figure 4-5. Nadir no. 7 viewport (nadir no. 2 similar).

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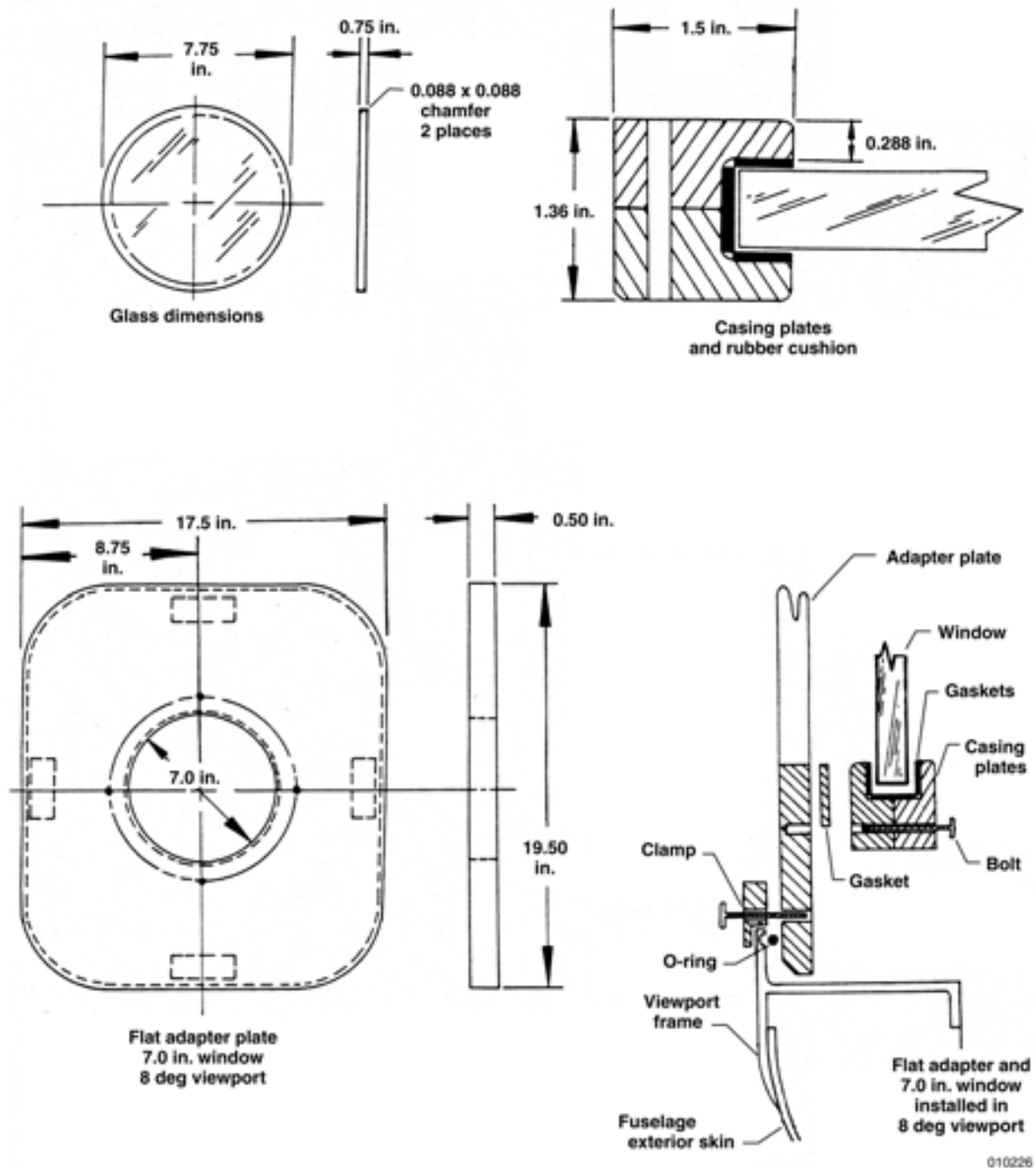
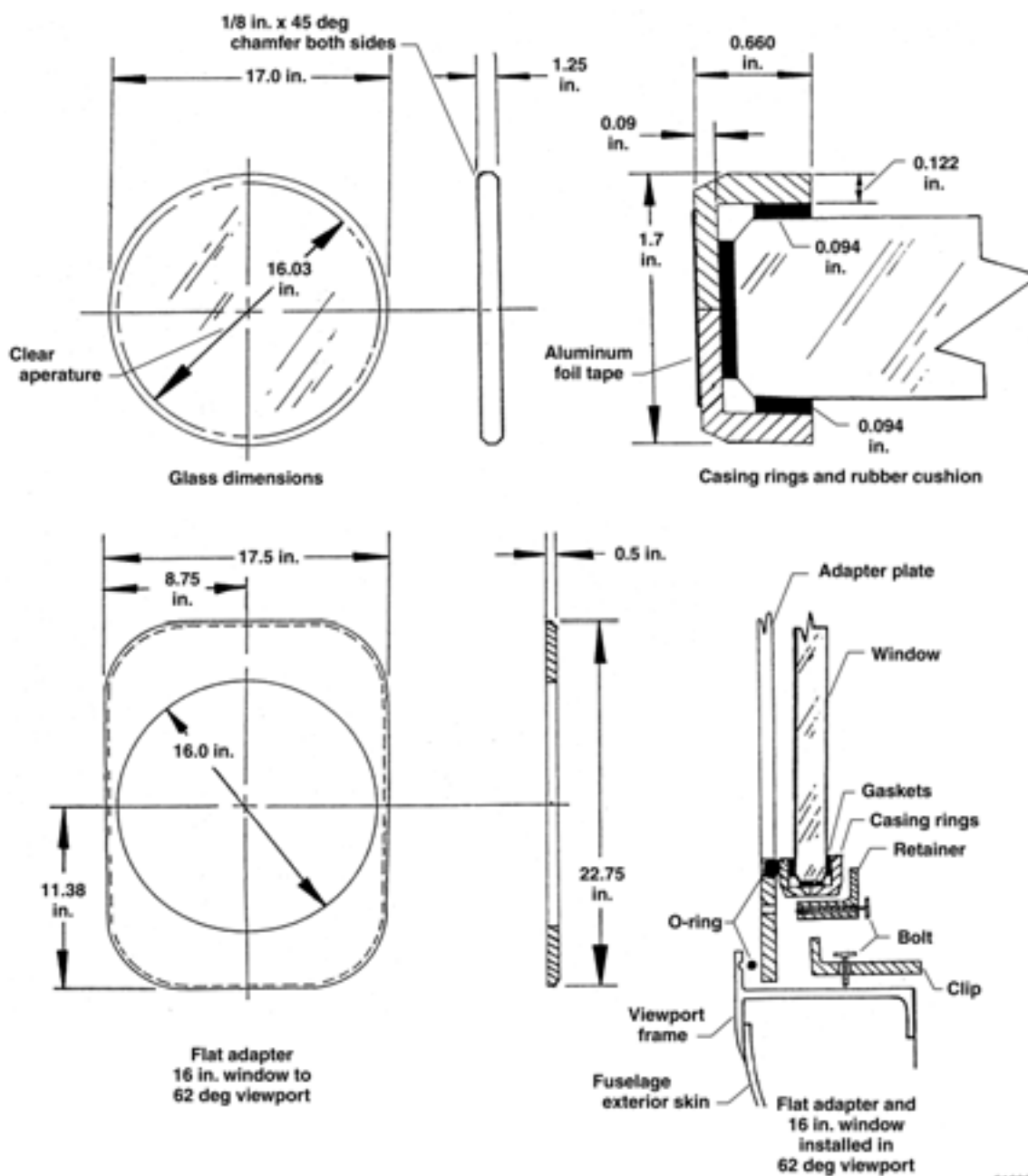


Figure 4-6(a). Optical viewport, frame and glass dimensions.

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Figure 4-6(b). Optical viewport, frame and glass dimensions.

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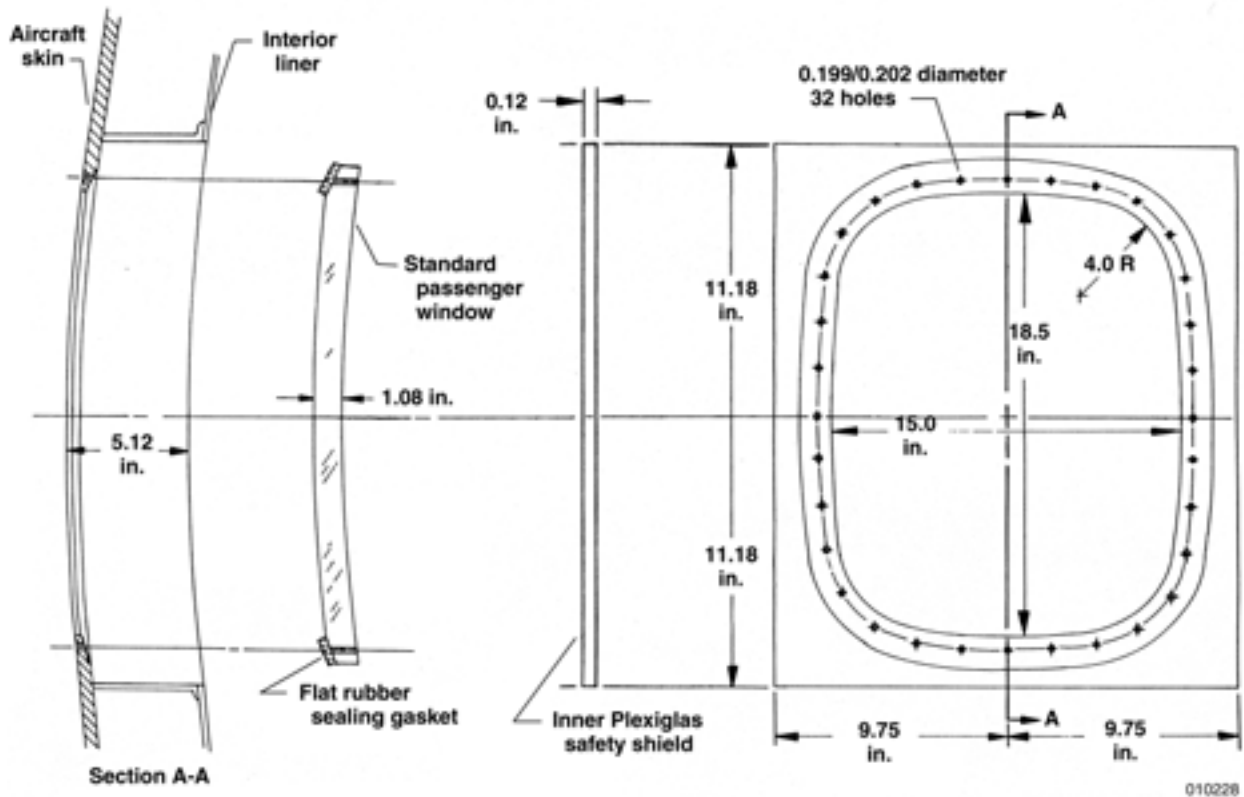


Figure 4-7. Standard unmodified passenger window.

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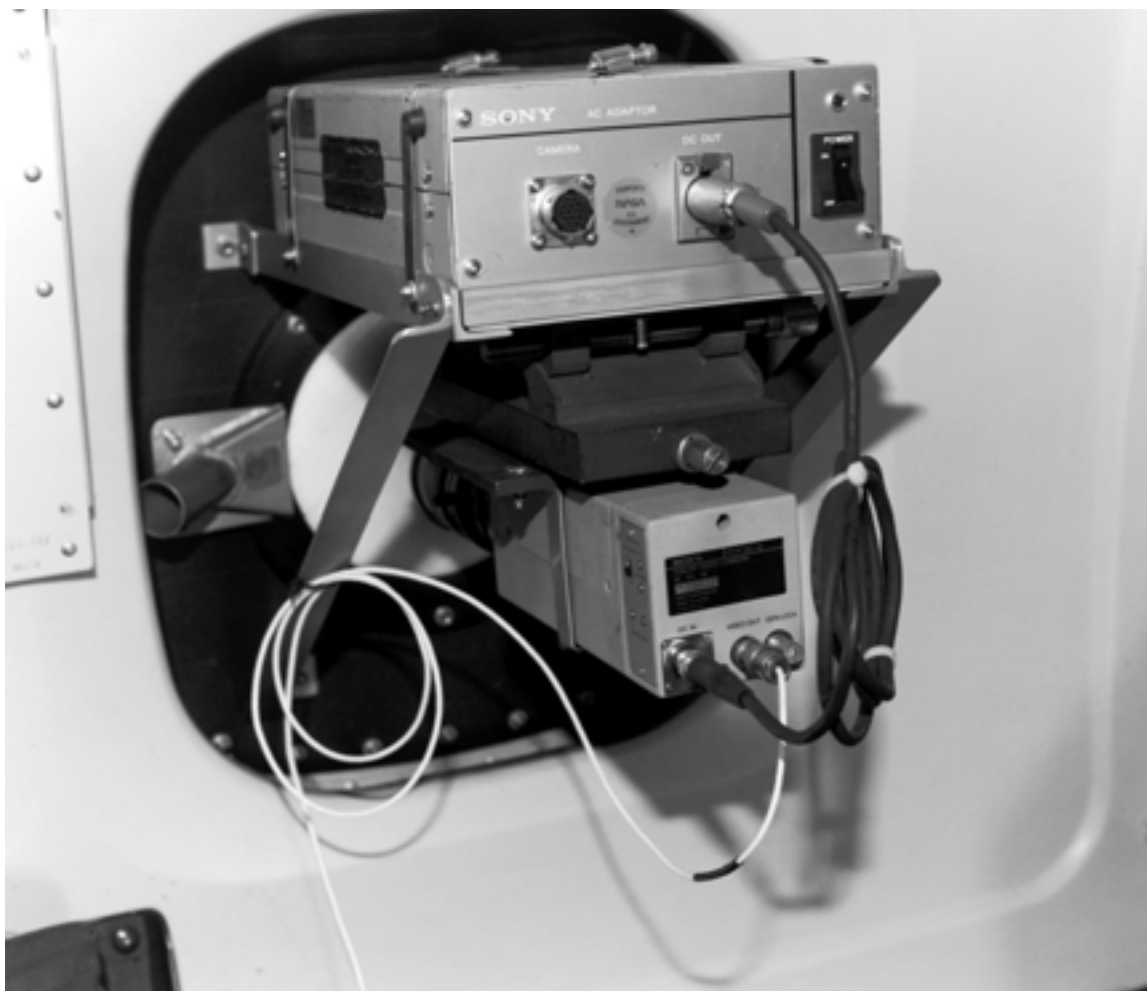


Figure 4-8. Radiometer on 8 ° insert panel.

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Table 4-2. Minimum thickness of window materials.

Material	Dimensions, in.		
	Outside Diameter	Clear Aperture Diameter	Minimum Thickness ¹
Soda Lime, Borosilicate Crown, Quartz, Fused Silica, Pyrex or Germanium	1.50	1.00	0.10
	2.50	2.00	0.20
	4.75	4.00	0.35
	6.75	6.00	0.50
	9.00	8.00	0.65
	11.00	10.00	0.80
	13.00	12.00	0.95
	15.00	14.00	1.10
Zinc Selenide ² , Arsenic Trisulfide Glass, Calcium Fluoride, Polyethylene, Polypropylene, etc.	17.00	16.00	1.25
	1.75	1.00	0.15
	2.75	2.00	0.25
	5.00	4.00	0.45
	7.00	6.00	0.65
	9.50	8.00	0.85
	11.50	10.00	1.05
	13.50	12.00	1.25
UHMW Polyethylene ³	15.50 (diagonal)	14.5 (diagonal)	1.60

¹. Minimum thickness allowed. Greater thickness is allowable up to the space available in the port system. Generally, the maximum thickness that can be accommodated is 1.25 in.

². Window thickness for materials in this group will be individually determined, based upon physical properties.

³. For non-circular windows, the minimum thickness is determined by the largest diagonal measurement.

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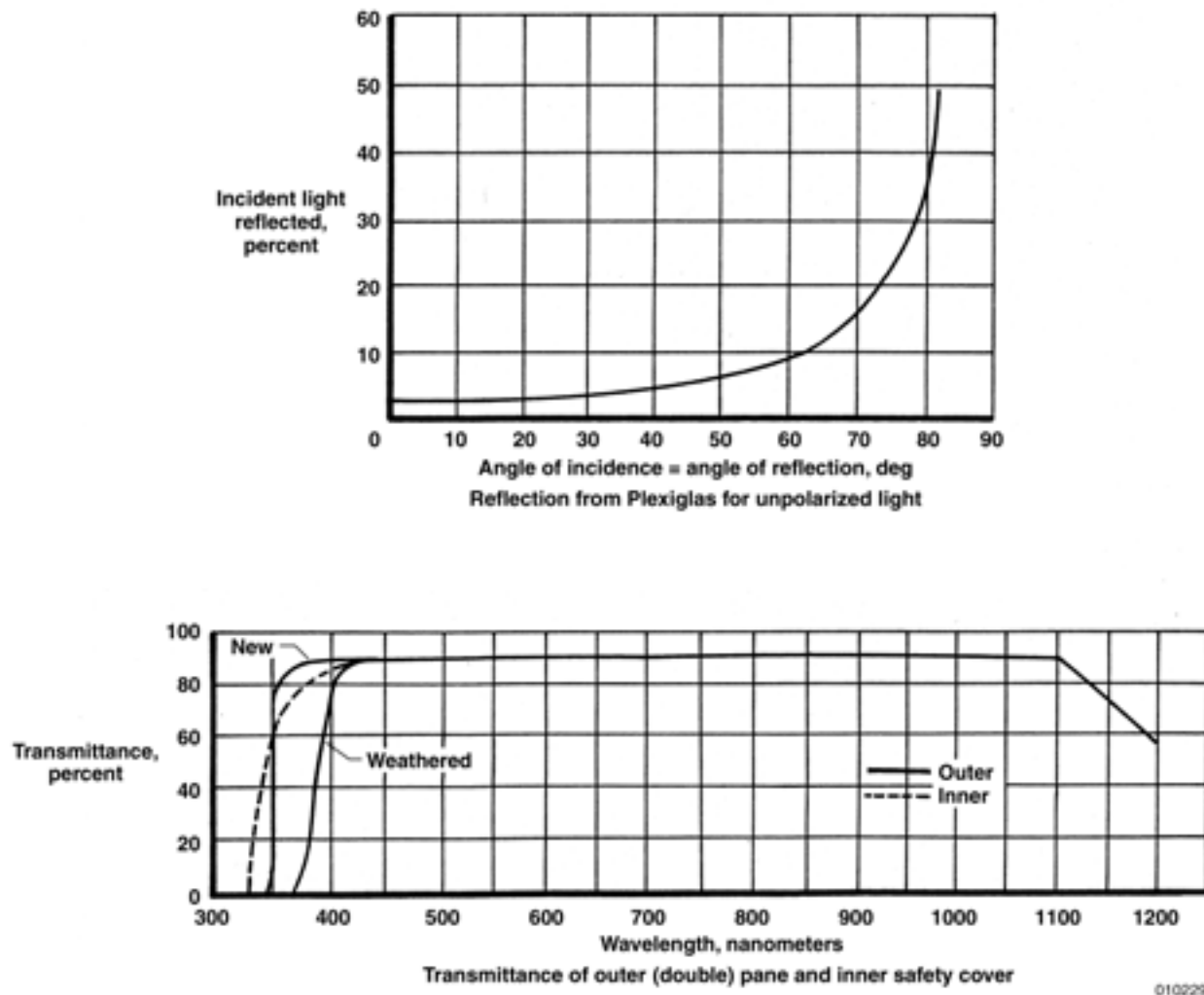


Figure 4-9. Optical characteristics of standard unmodified passenger windows.

The assembly is first subjected to a leak test by applying a pressure differential to the window and its mounting frame. This assembly is then subjected to a greater pressure differential at room temperature to proof test the glass. Then it is subjected simultaneously to a pressure and temperature differential to environmentally test the entire assembly. Obtain a copy of the "Airborne Science Optical Window Program Plan" from your mission manager, for window testing details.

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After testing, the window assembly is held in secured storage until installation. If any disassembly or alteration is required, this test must be repeated. The nominal test procedure may be tailored to a specific window material when an appropriate fracture analysis is available.

C. Precautions After Installation

Assembly, adjustment, or repair operations to an experiment near a window must be performed with a window safety shield in place. Equipment should be designed so operations of this type take place with the shield closed. A scratch, gouge or chip in the window is likely to immediately disqualify it from further use. Therefore, the space between the optical window and safety shield should never be used for storage of loose items.

A defogging system is available for each modified viewport. Air supplied by the cabin gasper air system is directed across a designated window with a manually operated valve controlling the flow. The defogging system is normally adequate to prevent frosting or fogging at high altitudes. However, in regions of high humidity, if the aircraft has been cooled at a high altitude and descends quickly to an altitude where the optical surfaces have temperatures below the cabin dew point, condensation can occur on the window. If observations are then to be made, the window must be manually cleaned with an appropriate solution by an aircraft crewmember. If windows need cleaning, special arrangements for engineering assistance should be requested through the mission manager.

6. External Airflow Parameters

A. Angle of Airflow Over Viewports

For experiments that have elements mounted external to the fuselage, it is important to know the angle of the local airflow over a viewport. Air sampling probes attached to window blanks are generally aligned with this angle to ensure proper operation. Table 4-3 shows the approximate airflow angle relative to the fuselage floor plane for the passenger windows. Tables 4-4 and 4-5 show the same information for 62° and nadir viewports. Note that these angles are for Mach no. 0.8, which represents cruise conditions. The angle varies slightly with speed and aircraft trim, therefore if designing for other specific conditions, you should request engineering assistance through the mission manager.

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Table 4-3. Inviscid flow over passenger ports, relative to fuselage floor plan.

Window Number *	Fuselage Station	Flow Angle, deg	Window Number *	Fuselage Station	Flow Angle, deg
1	290	1.7	16	891	-7.8
2	330	2.1	17	930	-8.7
3	370	2.4	18	970	-9.2
4	410	2.7	19	1010	-8.7
5	450	3.0	20	1050	-6.9
6	490	3.5	21	1090	-5.4
7	530	4.3	22	1130	-4.2
8	570	6.4	23	1170	-3.4
9	610	10.6	24	1210	-3.1
10	650	9.3	25	1250	-3.1
11	691	4.5	26	1290	-3.3
12	729	1.0	27	1330	-3.4
13	770	-2.0	28	1370	-4.3
14	810	-4.2	29	1410	-5.3
15	846	-5.8			

Fuselage angle of attack: 1 deg (cruise conditions), Mach no. 0. 8

* See Figure 3-1

B. Boundary Layer Thickness

A thin, variable thickness layer of air, known as the boundary layer, exists at the skin of the aircraft. The properties of this air do not represent free stream, undisturbed conditions; therefore, experimenters should place their devices far enough away from the fuselage to be in free stream air. Free stream conditions can be obtained by placing the sampling device at a spacing defined as approximately 1.2 in. per 100 in. of distance measured from the aircraft nose. Station numbers represent the distance, in inches, from the nose of the aircraft. For example, a probe placed in the first passenger window at station no. 290 must be spaced away from the fuselage by: 290×1.2 divided by $100 = 3.48$ in. (8.84 cm).

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Table 4-4: Inviscid flow over 62° ports, relative to vertical centerline and fuselage floor planes.

62° Viewport Number	Fuselage Station	Flow Angle Y-Direction, deg	Mach = 0.8 Z-Direction, deg
1	470	-1.4	0.8
3	1090	2.2	-1.2
4	1130	1.8	-1.0
8	1310	1.2	-0.7
+Y = Outboard +Z = Up Mach = 0.8			

Table 4-5: Inviscid flow over nadir ports, relative to vertical centerline and fuselage floor planes.

Nadir Viewport Number	Fuselage Station	Flow Angle Y-Direction, deg	Mach=0.8 Z-Direction, deg
2	420	0.0	0.0
5	1130	-0.8	-0.1
7	1200	0.0	-0.1
9	1310	-5.5	2.6
+Y = Outboard +Z = Up Mach = 0.8			

C. Fuselage Angle of Attack

At a Mach no. 0.8 and cruise altitude, the fuselage will have approximately a 1° angle of attack relative to the horizontal plane of the earth. Instruments that require an absolute line-of-sight should account for this angle in their design. Scanners and cameras are examples of instruments that often require an accurate nadir view.

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CHAPTER 5

EXPERIMENT CONSTRUCTION AND INSTALLATION

1. General Information

The installation of experimenters' equipment onto the aircraft is one of the most difficult and time-consuming aspects of airborne research. Accustomed to the relative ease of commercial airline travel, experimenters may not fully comprehend the problems encountered in the secure mounting of airborne test equipment to comply with the mandated safety requirements.

For this reason, adherence to the specifications, deadlines, and technical requirements listed in chapters 4, 5 and 6 is expected.

NOTE: Due to manpower limitations, major engineering and/or construction defects cannot, ordinarily, be corrected during equipment installation. Therefore, in the past, some experimenters with unacceptable equipment have been required to withdraw at the last moment. Careful adherence to the standards described in this chapter, and the procedures and timing for equipment certification (see Equipment Certification and Hazardous Equipment and Materials Certification, sections 8 and 9 of this chapter), will ensure a relatively trouble free installation. These standards fully meet or exceed all FAA mandated safety requirements for DC-8 type aircraft.

2. General Arrangement

The mission manager customarily prepares the aircraft floor plan. The plan is based on experimenters' requirements, equipment, auxiliary systems and seating. In certain cases, however, a partial floor plan may be proposed by another organization, coordinating the efforts of several different experimenters. Individual requests for specific locations, as well as proposals with partial floor plans, will observe the following restrictions.

A. Exit Areas

Cabin exit areas and the forward and rear interior cargo access hatches will be kept clear at all times. A single overwing exit may be blocked, depending on cabin configuration.

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B. Aisles

An aisle at least 20 in. wide, along the entire length of the main cabin, will be maintained.

C. Seat Spacing

The nominal passenger seat spacing is 38 in. (96.5 cm). Between the forward edge of any passenger seat and the aft edge of an instrument rack, 15 in. (38.1 cm) nominal is allowed. There is a center-located armrest which extends 3 in. (8 cm) forward of the seat cushion and is 26 in. (66 cm) high. Drawers mounted in outboard bays of standard instrument racks should be installed 27 in. (69 cm) above the floor to avoid obstruction.

D. Unavailable Areas

The housekeeping rack, the navigator console, and the mission director console are positioned between station 265 and station 480 on the right side of the cabin. This area is not available for experimenter equipment.

E. Cargo Areas

Limited cargo compartment floor areas are available to experimenters. On flights based away from DFRC, cargo space must be reserved for aircraft spare parts, aircraft support equipment, and baggage. This may require shipping experimenter support equipment to forward locations well in advance of actual DC-8 deployment.

3. Construction Guidelines

The design of aircraft systems and equipment installations for use on the DC-8 shall follow standard aircraft industry design practice and Douglas Aircraft design criteria. In addition, current FAA certification standards are to be met to the maximum extent practical, consistent with the intended mission of the payload. For more complete coverage of the design requirements, contact DFRC for a current copy of "DC-8/N817 Design Requirements." Brief guidelines for the construction of experimenter equipment follow.

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A. Load Factors

1) Passenger Cabin and Cargo Areas

All structures, attachments and fasteners for racks, instruments, pallets, tie-down retainers, carry on items, etc. must be designed to withstand the load conditions listed below. These load factors, when applied one at a time, must not produce a stress in any structural element of the equipment beyond the accepted ultimate strength of that construction material.

Table 5-1. Minimum crash load design criteria.

Load Direction	Ultimate Load Factor, g	
	Passenger Cabin	Cargo Compartments
Forward	9.0	3.0
Down	4.5	4.5
Up	2.0	2.0
Lateral	3.0	1.5
Aft	1.5	1.5

The load factors listed are for the structural design of the equipment only. It is not required that alignment, calibration, or other instrument functions be maintained under these load conditions.

2) External Attachments

All external structures must be designed to withstand the maximum aerodynamic and gust loads encountered. A safety factor of 2.25 is applied to each of the maximum loads (except gust loads). Then the appropriate sums are compared with the accepted limits of the fabrication materials and surrounding structure. Close coordination with DFRC is advised.

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B. Design Pressures - Cabin Environment

In general, experiment structures (other than optical windows) designed to act as a critical component of the aircraft's pressure vessel shall be designed to ultimate pressure, 2P (see table 5-2) plus flight loads and aerodynamic pressure or suction effects.

It is the policy of DFRC Airborne Science Directorate to design such structures at DFRC to experimenter requirements. Exceptions to this procedure require consultation, review, and approval of the mission manager and operations engineer prior to fabrication.

Table 5-2. Minimum pressure vessel design criteria.

Design Parameter	Pressure Limit, psi
Maximum Cabin Differential Pressure	8.77
Maximum Emergency Relief Pressure (P)	9.27
Design Limit Pressure	$9.27 \times 1.33 = 12.33$
Design Ultimate Pressure (2P)	$9.27 \times 2 = 18.54$
External Fuselage Pressure (Ditching)	Variable, depending on station number. Up to 15 psi on initial impact in the tail section and 12 psi in the nose due to pitch-over.

C. Materials

Aircraft structural material should be used on the design of special load-carrying supports. Aluminum such as 2024, 6061, and 7075 is readily available for this purpose.

Experimenters designing their experimental equipment should avoid using flammable materials or materials that emit toxic fumes. For example, the external cabling of commercial electronic components must have self-extinguishing insulation, such as Teflon or Tefzel. Accessories such as cable ties, clamps, or identification sleeves must be of a similar material (see chapter 6).

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Polyvinyl Chloride (PVC) is not approved for use in airborne applications. Experimenters should carefully review their drawings and parts lists to insure that PVC insulated external wire or cable, or PVC hose is not specified. Internal wiring of commercial off-the-shelf products, such as computers, is excepted. PVC products cannot be used on the aircraft due to the highly toxic fumes and dense black smoke emitted upon exposure to high temperature (see chapter 6).

The use of toxins, flammable gases, or corrosive liquids must be approved by the mission manager prior to planning for an experiment. See section 9 of this chapter for additional information about certification of hazardous materials.

D. Welding

Welding structural members of experimental equipment may be acceptable; however, bolting and/or riveting are preferred. Welded structures should be avoided for significant load bearing and/or externally mounted structure. Where necessary, use stainless steel or steel. When welding is required, a welder who is currently certified to AMS-STD-1595 specifications must perform it. The assembly should then be heat-treated, if full joint strength is required. The welds must be performed in accordance with the "Fusion Welding for Aerospace Applications" SAE-AMS-STD-2219 specification. Proof of conformance to both specifications must be submitted with the welded assembly. If this is not done, the assembly will be subjected to rigid NASA DFRC inspections and, if not passed, may not be permitted on the aircraft. Care must be taken to use only materials suitable for welding. Welding is not permitted on the aircraft.

E. Fasteners

Standard aircraft structural fasteners (MS, NAS, or the equivalent) must be used for all structural members and must be secured by some locking method (such as self-locking nuts, lock washers, cotter pins, or safety wire.) This requirement includes the installation of components into standard DC-8 equipment racks, and mounting on other support frames or aircraft hard points. These types of fasteners should also be used for other elements of the equipment whenever possible.

Data sheets, giving detailed nomenclature and the engineering specifications for this type of hardware and a list of suppliers is available on request.

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F. Hydraulic or Pneumatic Systems

Hydraulic and pneumatic lines and fittings should be aircraft quality, or equivalent, and should operate at the lowest pressure possible. Fluids should be non-flammable, non-corrosive, and non-toxic.

G. Alignment With Existing Hardpoints

Experimenters' equipment to be attached to aircraft hardpoints, existing shelves, viewport Brownline rails, or to the top of DC-8 standard racks, should be match-drilled at assembly. Local fitting dimensions may vary slightly from nominal values, and safety requirements may preclude the use of slotted or enlarged holes to obtain a fit.

H. Aircraft Fuselage Penetrations

Fuselage penetrations larger than one-half in. diameter from the pressurized areas of the aircraft to the aircraft exterior for probe inlet or exhaust tubes require shutoff valves. The valve should be located in the proximity of the bulkhead penetration.

4. Aircraft Vibration

In-flight vibrations are generally not a problem for experimenters as the DC-8 exhibits a low level of vibration characteristic of large jet aircraft. Figure 5-1(a), 5-1(b), and 5-1(c) show the in-flight vibration spectra in five areas of the aircraft.

Vibration frequencies and amplitudes imparted to experimental equipment are subject to the widely varying contribution of different mounting structures. If instrument components are sensitive to any of the frequencies at the power densities shown, then it is recommended that isolation mounts for these components be considered in the over-all design of equipment. Captive-type isolators should be used.

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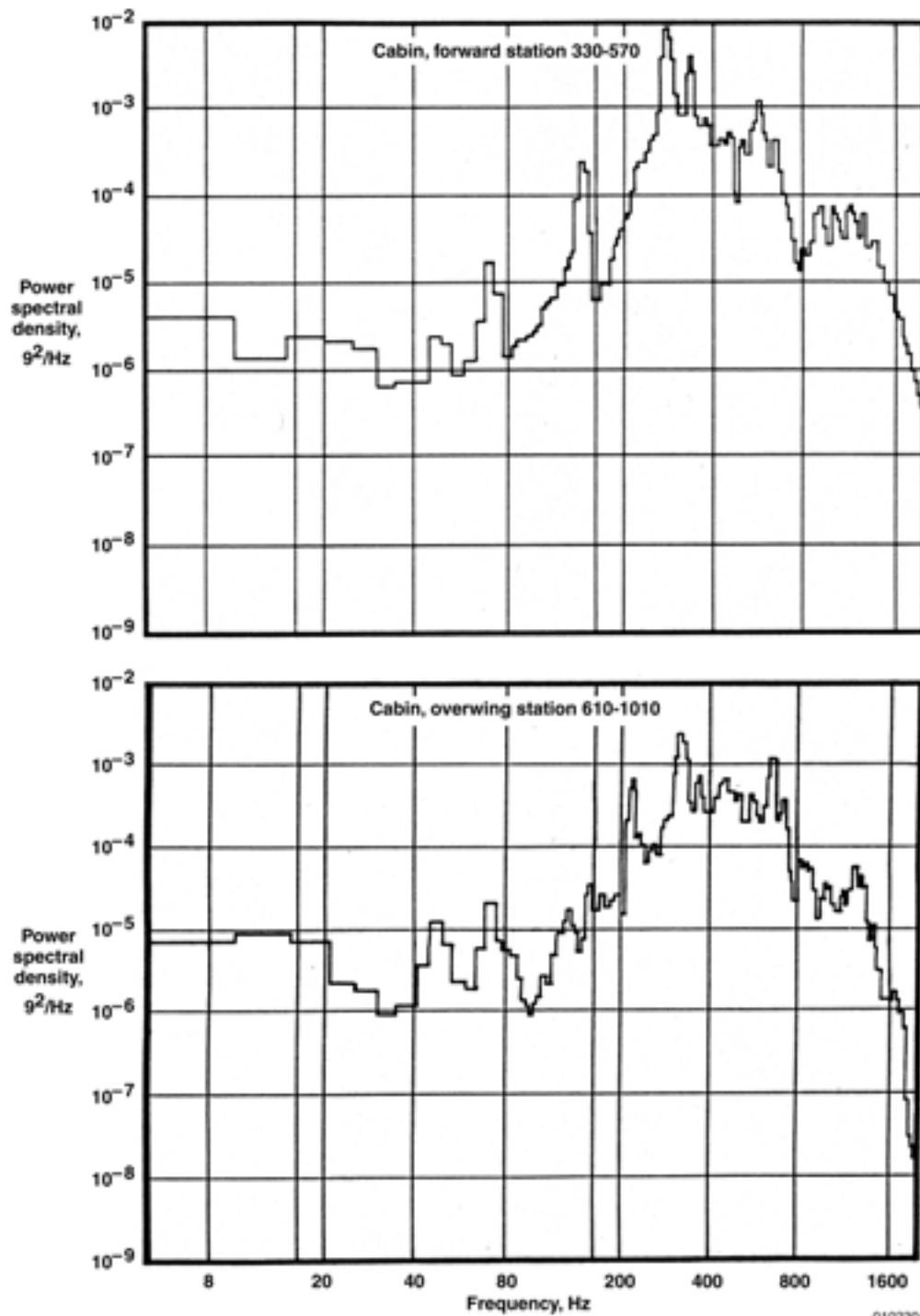


Figure 5-1(a). In-flight vibration spectra.

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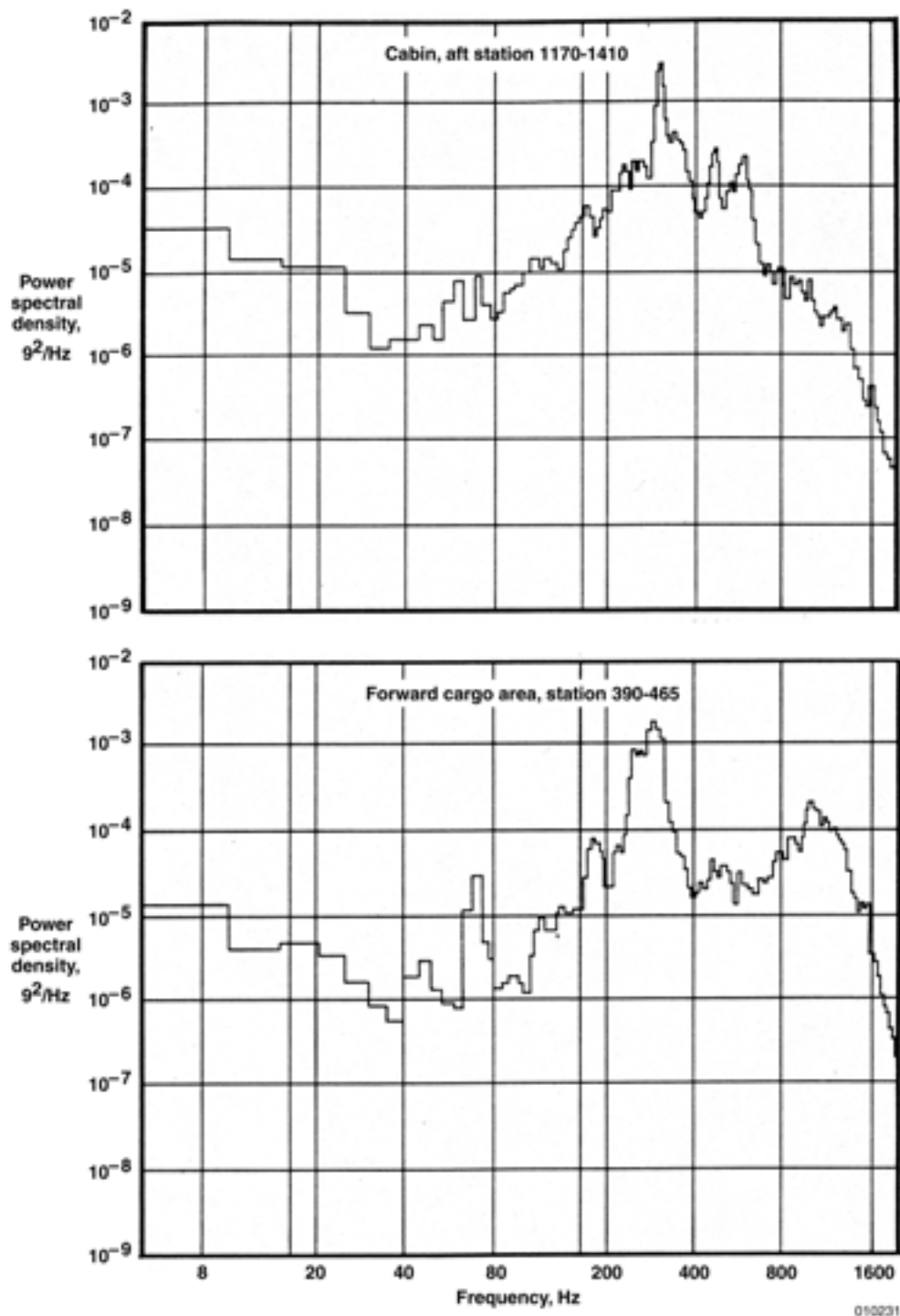


Figure 5-1(b). In-flight vibration spectra.

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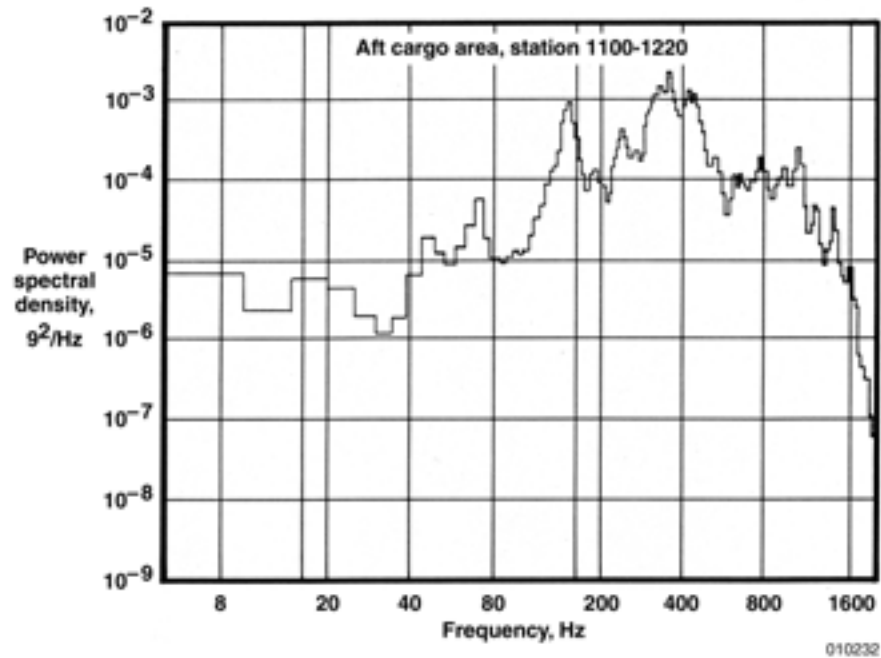


Figure 5-1(c). In-flight vibration spectra.

Experimenters should remember that, except for air turbulence, the most severe vibration usually occurs during taxi, take-off and landing. For example, on rough runways, printed circuit cards and connectors have become dislodged, and optical components have been jolted out of alignment. Mechanical support, by clamps, brackets or dampener should be provided as a precaution, for such problems may prove difficult to correct in flight. Representative values for these conditions are one-quarter to one-half at 10 Hz and below.

The DC-8 mission manager should be consulted for specific guidance on vibration-related concerns. Arrangements can be made for component tests at DFRC, if required. The test facility generates sinusoidal forces up to 8,000 lb, at frequencies from 5 to 2,000 Hz, and random forces up to 5,000 lb. Components up to 24 in. in size can be tested, one axis at a time, at accelerations up to 100 g.

5. Structural Attachments

Guidelines follow for the attachment of experimenters' equipment to the aircraft.

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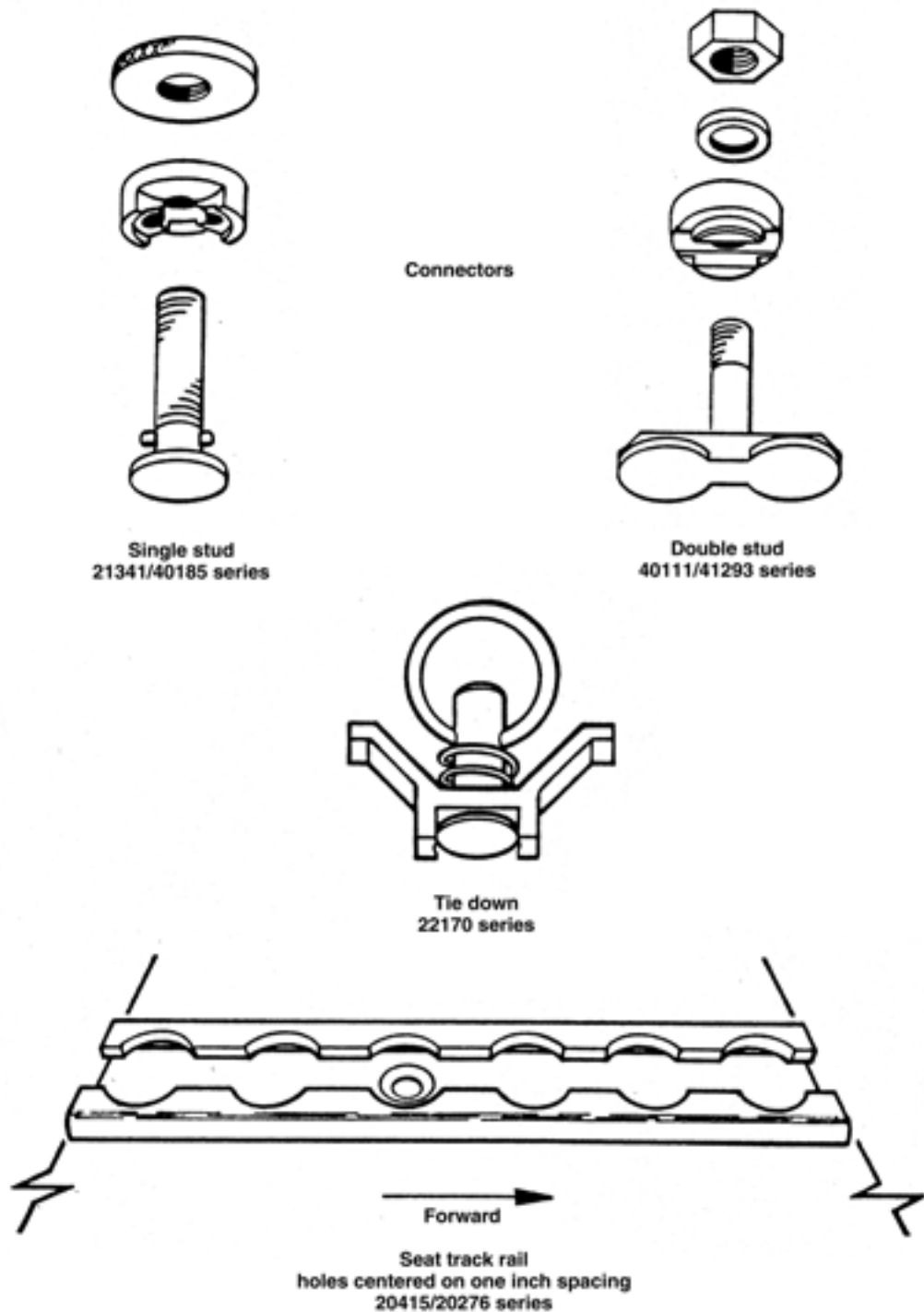


Figure 5-2. Seat rails and clamps.

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A. Aircraft Cabin

Structural attachment in the cabin area will be primarily accomplished by connection to seat and viewport rails.

1) Seat Rails

A pair of rails on each side of the main cabin floor is used to attach the passenger seats, using special fittings (figure 5-2). These same fittings are also used to attach experiments to the seat rails and to the viewport Brownline rails. The maximum allowable loads that can be applied to each of the floor rail fittings are given in figure 5-3.

2) Viewport Rails

Brownline rails in fore-aft orientation at the top and bottom of each viewport can be used for experiment attachment. Only shear and/or tension loads are permitted at these rails. Therefore, single stud attachment of hardware to the rails, that will cause a moment reaction to the rail, will not be permitted.

B. Cargo Compartments

Experimenter equipment can be mounted (to the Brownline rails) in both the forward and aft cargo compartments. Due to the limited floor space available on flights based away from DFRC, cargo compartment installations should be discussed beforehand with the DC-8 mission manager.

The cargo loading doors open inward, sliding along the curved hull of the aircraft. Equipment installations must not interfere with the movement of these doors (figure 3-4).

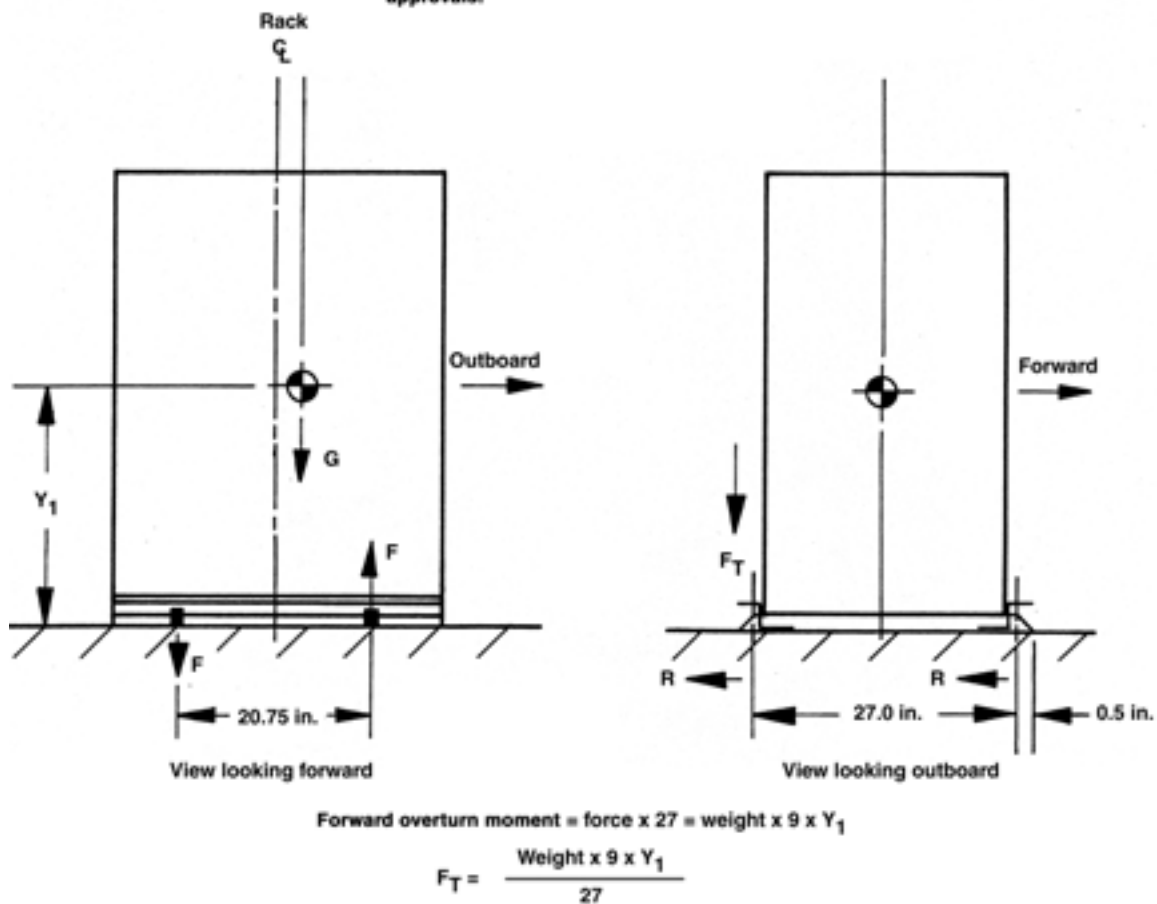
C. Other Equipment Mounting Locations

It is possible to mount experimenters' equipment on the exterior of the aircraft at certain specified locations. All such requests must be considered individually. Experimenters who consider installations of this type should visit DFRC at least twelve months in advance, to examine the aircraft and discuss plans in detail with personnel.

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Maximum applied load per connector (Including load factors)	
Tension	5,000 lb
Shear	5,000 lb
Bending	2,300 in. lb

Note: When connectors are subjected to combined loads. The above limits may be reduced. Contact DFRC for specific requirements and approvals.



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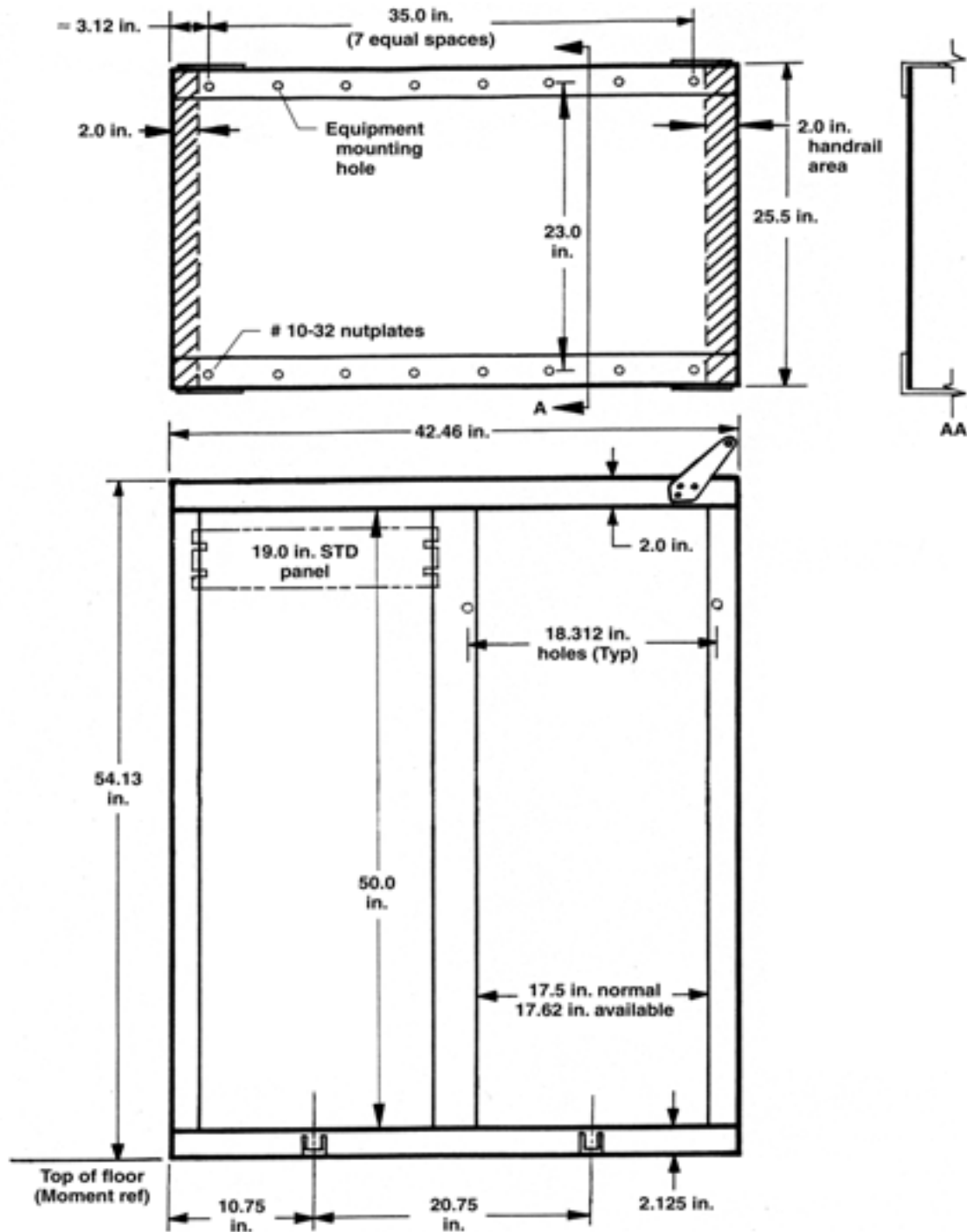
Figure 5-3. Loads for a standard rack and connectors.

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Figure 5-4(a). Standard equipment racks – high rack.

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Figure 5-4(b). Standard equipment racks – high rack – dimensions.

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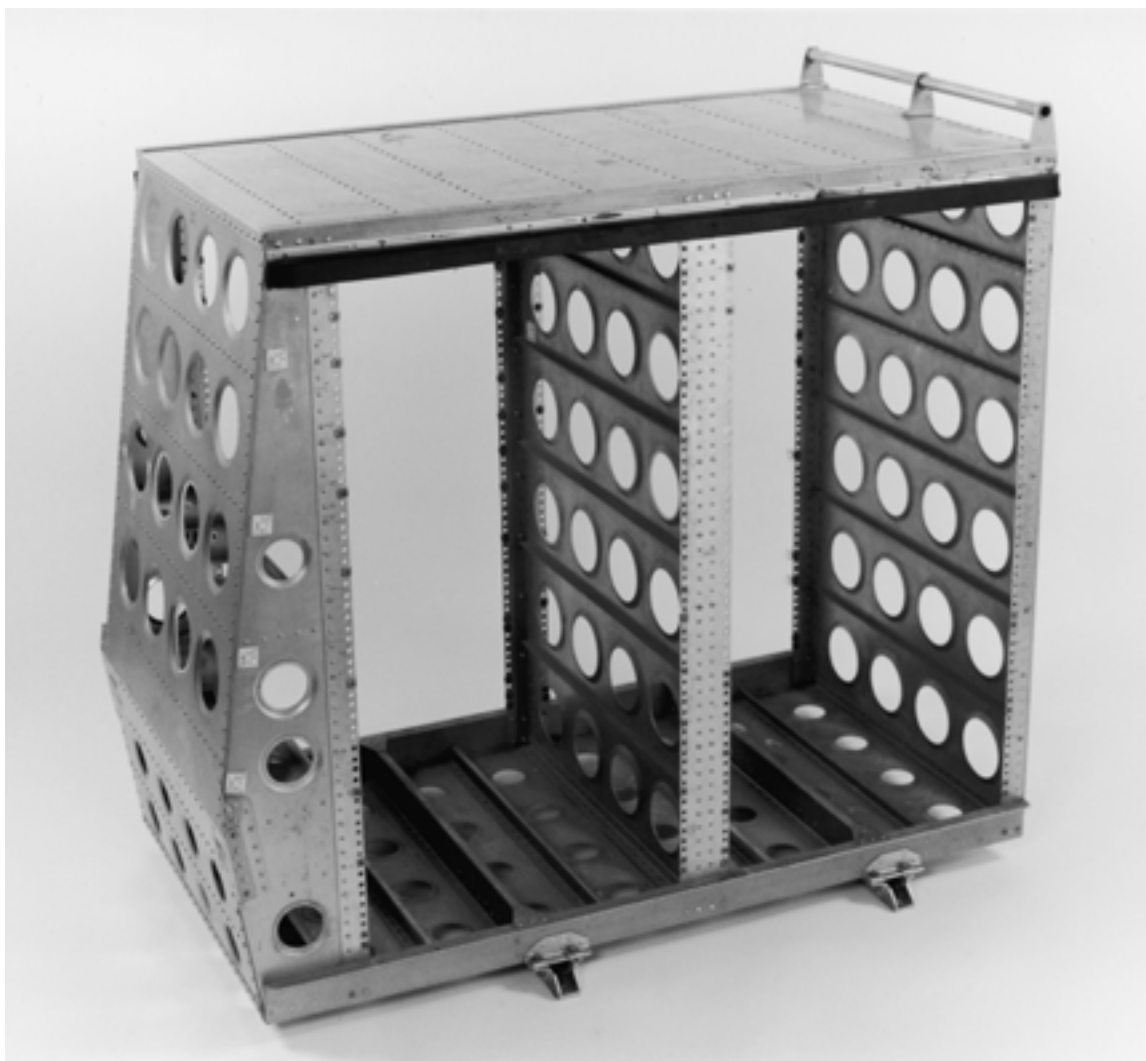


Figure 5-5(a). Standard equipment racks – medium rack.

The drawing consists of two views of a handrail assembly:

- Top View (Upper):**
 - Overall width: 43.72 in.
 - Overall height: 24.19 in.
 - Top edge features a 0.093 in. step.
 - Top edge has 7 equal spaces of 35.0 in. each, secured with # 10-32 nutplates.
 - Equipment mounting holes are typical.
 - A stay-out area (handrail) is indicated on the left side, with a width of approximately 2.0 in.
 - A section line A-A is shown.
- Side View (Lower):**
 - Overall height from top of floor: 42.90 in.
 - Handrail height: 2.45 in.
 - Internal dimensions include a 19.0 in. STD panel and a 35.0 in. section.
 - Horizontal dimensions include 1.60 in., 2.50 in., 17.50 in. normal (17.62 in. available), and 18.312 in. holes.
 - A moment reference is indicated.
 - Base dimensions from top of floor: 9.50 in. and 20.75 in.
 - Small vertical dimensions at the base: 2.50 in. and 1.70 in.

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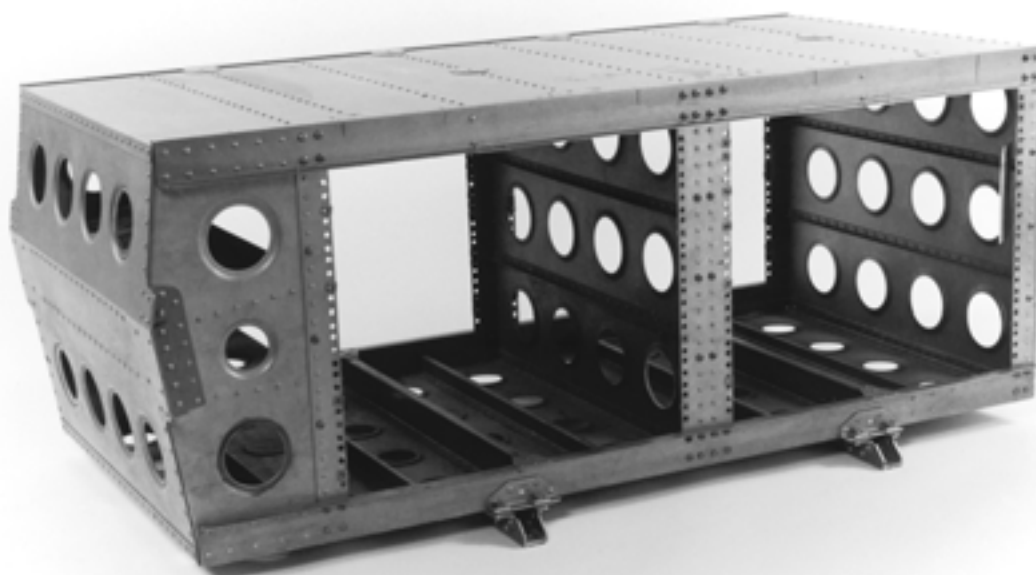


Figure 5-6(a). Standard equipment racks – low rack.

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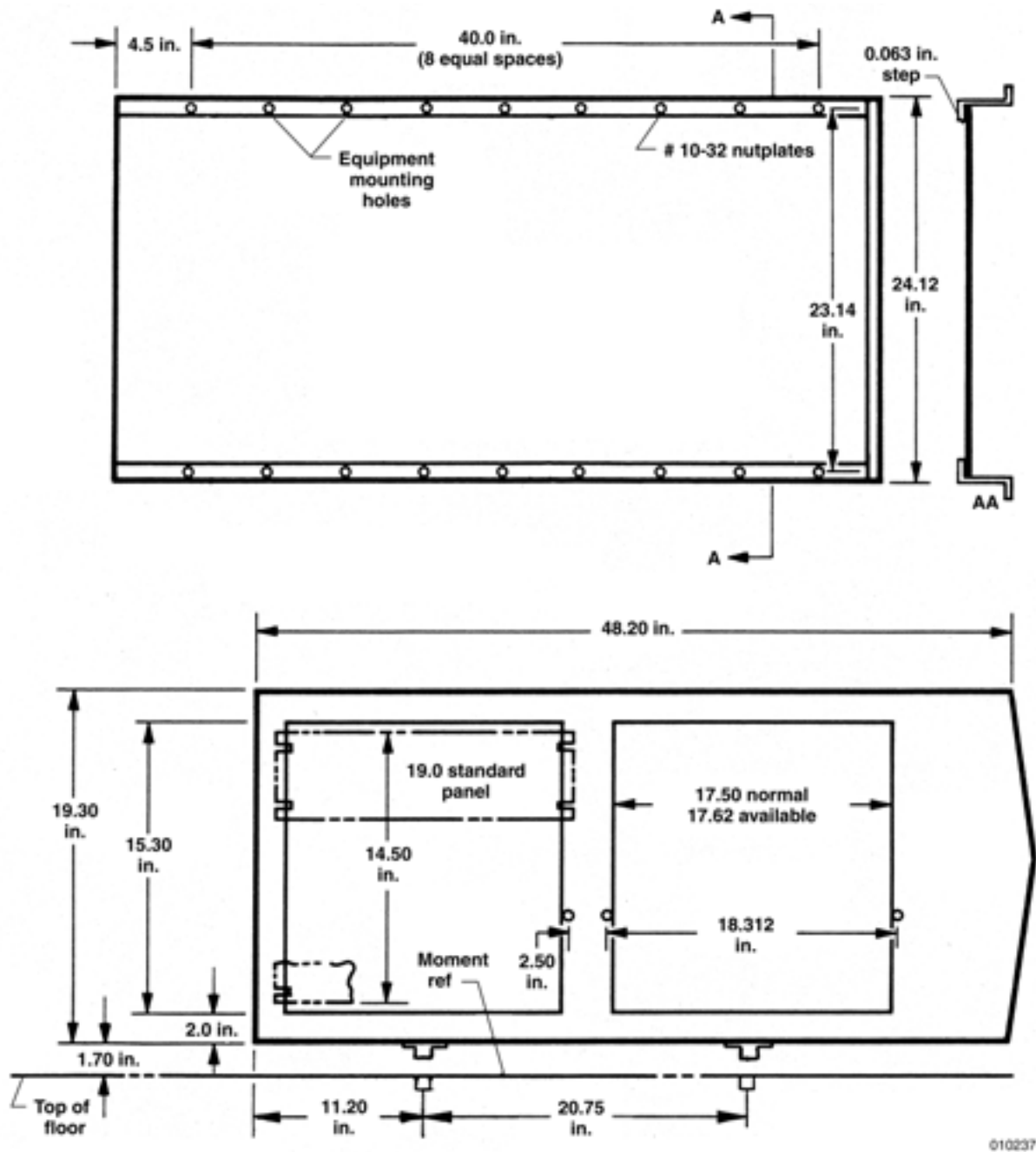


Figure 5-6(b). Standard equipment racks – low rack – dimensions.

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6. Standard Equipment Racks

Equipment racks that fasten directly to the seat rails have been designed for use in the aircraft main cabin. The racks are designed to accept standard rack-mounted test equipment, 19 in. (48.3 cm) wide, and are available to all experimenters. The racks are available in three sizes: a high rack with two bays, each 50 in. (127 cm) high by 25 in. (63.5 cm) deep, as shown in figure 5-4(a) and 5-4(b); a medium rack with two bays, each 35 in. (88.9 cm) high by 24 in. (61.0 cm) deep, as shown in figure 5-5(a) and 5-5(b); and a low rack with two bays, each 14 1/2 in. (36.8 cm) high by 24 in. (61.0 cm) deep, as shown in figure 5-6(a) and 5-6(b). Equipment can be mounted on either side of the racks facing both forward or aft.

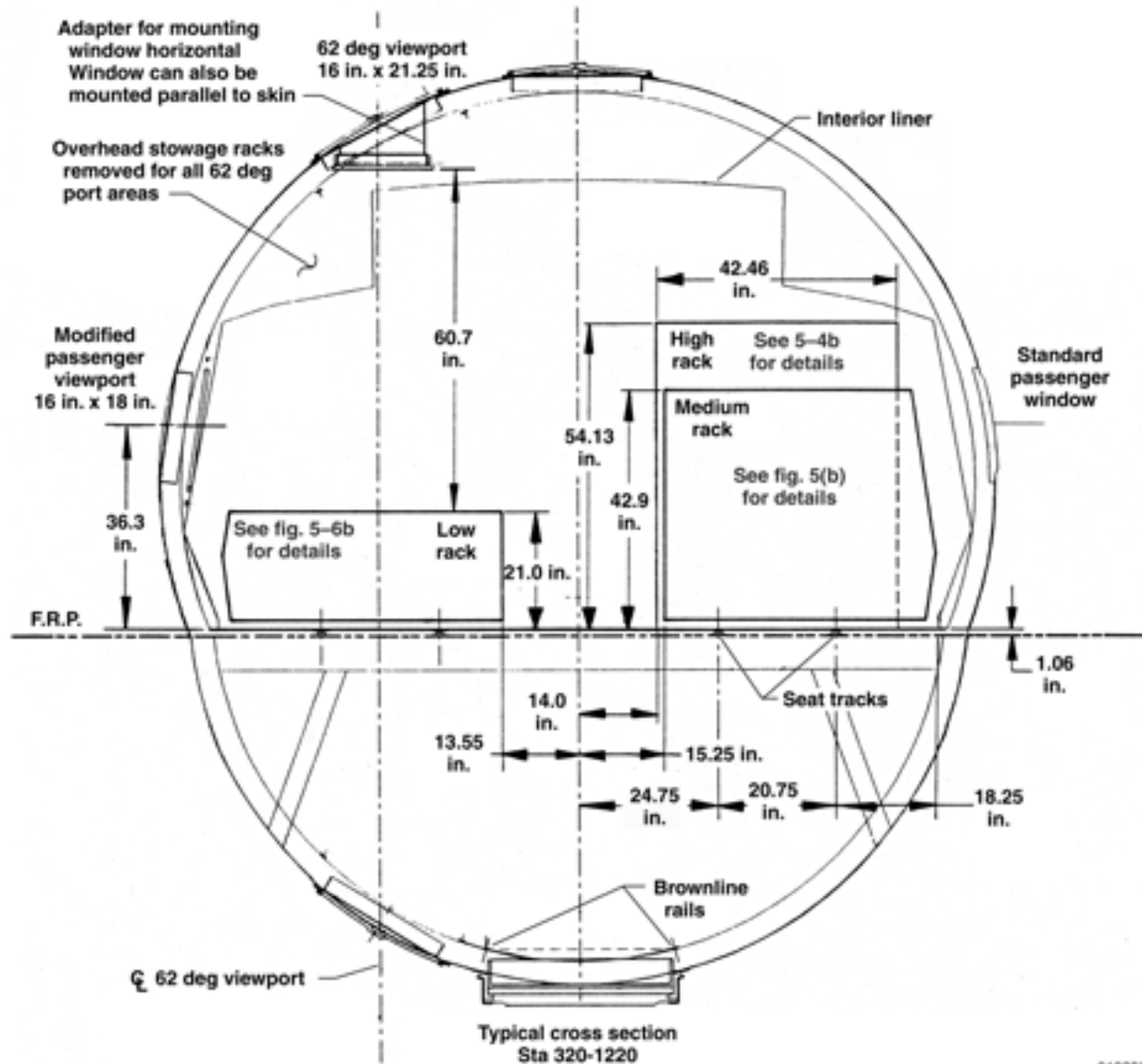
The maximum allowable equipment (or tare) weight for low and medium racks is 300 lb (136 kg) per rack bay; for high racks, it is 450 lb (204 kg) per rack bay¹. These weights include any equipment mounted on top of the racks. The total allowable overturning moment for all equipment, in or on low and medium racks is 6,000 in.-lb per rack bay; for high racks, it is 9,000 in.-lb per rack bay. Moment arms are measured vertically from the floor level to the center-of-mass of each component. These weight and moment values take into account the load factors and allowable loads and do not include the weight of the rack itself. Stress analysis of rack structure or rail attachments is not required, except for nonstandard installations.

The equipment racks are often used as support platforms for mounting equipment. The high and medium racks are used for experiments utilizing overhead viewports, and the low rack for those utilizing the passenger viewport or windows, as well as for other heavy equipment. Experimenters should consult with the mission manager when planning to use the top of any rack to mount equipment. These types of installation requests are considered individually and may, in certain cases, require stress analysis even though the weights and moments do not exceed the values listed. The positions of the high, medium, and low racks relative to the viewports are shown in figure 5-7 to assist the design of rack-top mounts.

NOTE: Modifications to the standard equipment racks, however minor, are not permitted under any circumstances.

¹. For rack loads approaching limiting values, the lateral center of gravity should be located at the vertical center post. Deviations from this requirement may reduce the allowable weight for all racks.

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Figure 5-7. Installed equipment racks and viewports, cross section.

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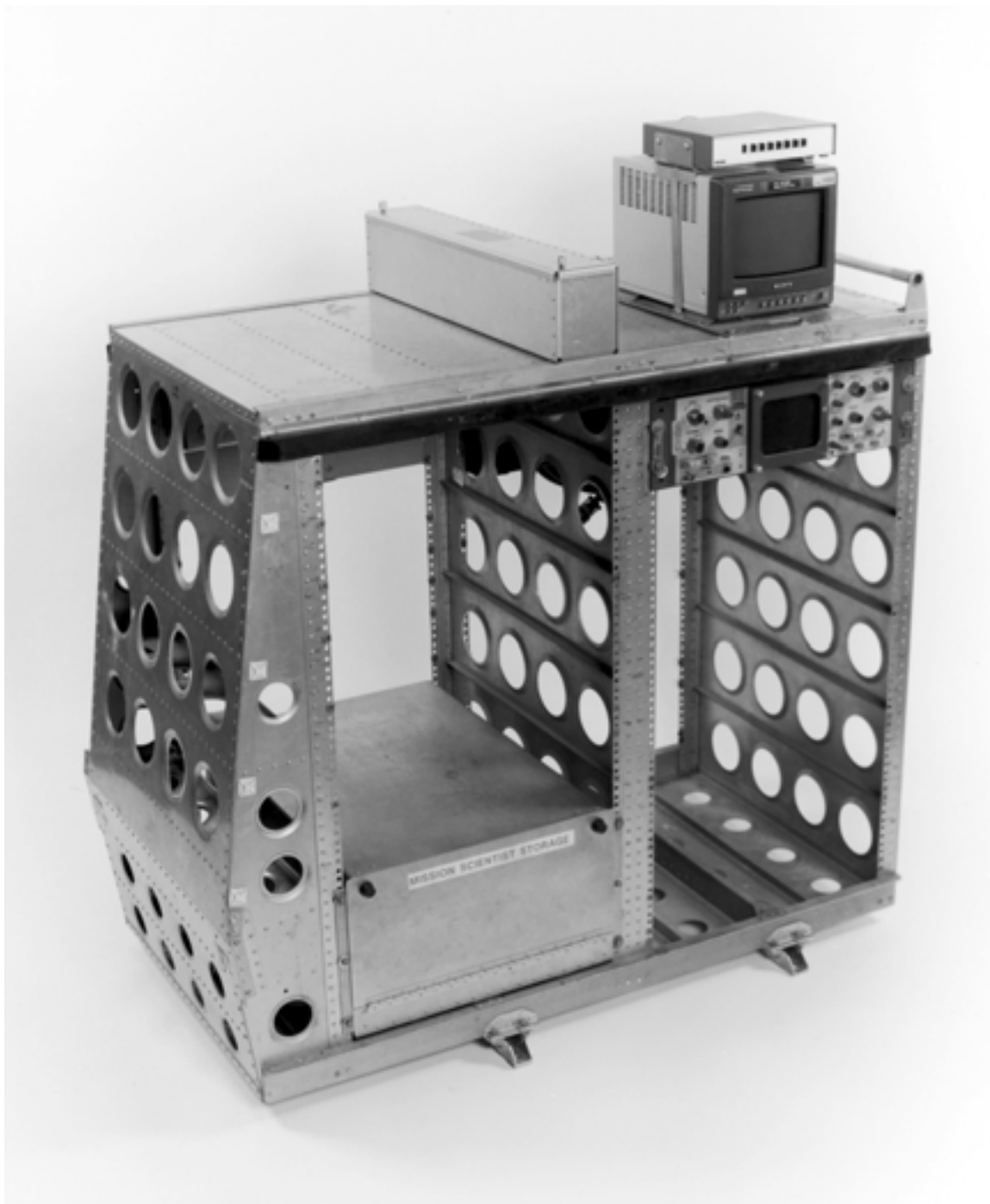


Figure 5-8. Typical installation in equipment rack.

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Experimenters are requested to make preliminary scale layouts of their equipment in the racks (calculating allowable loads and moments given earlier), and to prepare a list of sizes and weights (panel height, depth, and individual weight). Further, it is advisable to place the heavier items near the bottom whenever possible, to reduce the overturning moment. DFRC will use this information to check loading and moments, and to determine the internal support and bracing required to distribute the loads to the rack structure. For help performing these calculations, contact the mission manager to request engineering assistance.

7. Mounting Techniques

All articles, regardless of size, must be secured during takeoff and landing. When airborne, it is permissible to relocate items that are necessary for experiment operation or maintenance and that weigh less than ten lb (4.5 kg). Because of the potential for air turbulence, however, those items should be secured again after relocation. Personal possessions such as bags, briefcases, cameras, laptops, and binoculars are included in this requirement.

A. Cabin Area

The preferred method of mounting equipment is to use the standard racks. Equipment with standard 19 in. (48.3 cm) panels can often be mounted directly into the vertical support rails.

Refer to appendix A for guidelines to the mounting of individual items of equipment in the experimenter racks. A supply of rack-mounted support trays is in stock at DFRC. Typical examples of their use are shown in figure 5-9.

When a rack is shipped to an experimenter for equipment installation, a supply of clip nuts, NAS fasteners, and trays can be included if arranged in advance. Since unique support requirements cannot be anticipated, experimenters are encouraged manager for engineering assistance.

Smaller components and components without mounting panels can be supported on solid trays of structural-grade aluminum (figure 5-9 and appendix A). These trays span the full depth of the rack and have flanged edges for stiffness and to expedite attachment to the vertical rails.

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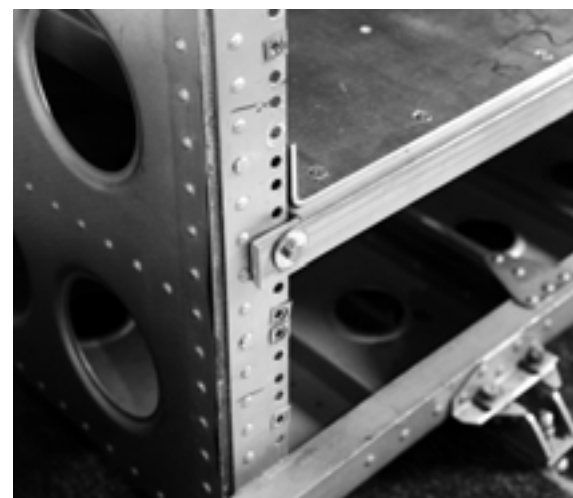


Figure 5-9. Typical tray mounting configurations.

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Figure 5-10. Typical equipment mounting techniques – 62° Viewport.

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Figure 5-11. Typical equipment mounting techniques – low rack.

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NAS-type fasteners must be used throughout the rack assembly. Contact DFRC for suggestions on mounting such equipment.

Certain types of equipment, due to size, shape, or orientation, cannot be mounted in the standard racks, and require special mounting arrangements. In all cases, including use of a standard equipment rack for supporting equipment, the experimenter should design, stress-analyze, and fabricate the entire structure. Where circumstances warrant, and within the limits of the available manpower, the mission manager can make arrangements for design and fabrication support, with the cost charged to the experimenter.

Generally, rack-top mounts use intermediate support plates, which attach to the equipment and span the top surface. These supports are then match-drilled to the existing fittings at the rack edges (figures 5-4 through 5-6).

All experimenters' equipment in the main cabin, except for small and light components attached to the viewport rails, must be supported by the seat tracks. Some examples of equipment mounting techniques are shown in figures 5-10 and 5-11.

For equipment that cannot be adapted to the standard rack support structure, two techniques are recommended:

- Equipment can be mounted on a framework that attaches directly to the seat rails. This method is especially applicable for equipment positioned for viewing or sampling through viewports (figure 5-12).
- An aluminum pallet can be attached to the seat rails and the equipment then mounted to the pallet. Equipment can also be bolted to the brackets restraining the pallet or attached to it by means of base-plates (figure 5-13).

NOTE: All non-standard mounting designs must be approved by NASA-DFRC engineering. Structural certifications and receiving inspections are required prior to installation and flight.

NOTE: Do not pre-drill equipment mounting holes prior to installation at DFRC. Nonstandard equipment will be match-drilled at installation to fit the seat rails.

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Figure 5-12. Large experimenter equipment mounted on special framework.

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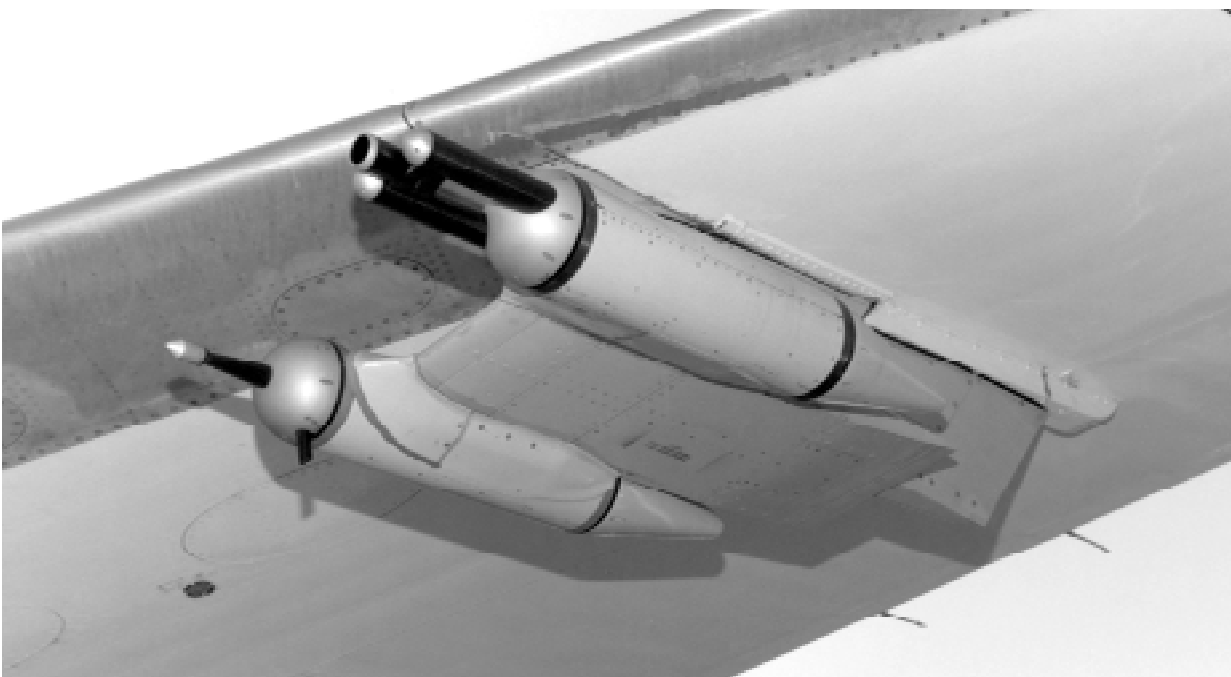


Figure 5-13. Large experimenter equipment mounted on special framework.

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Figure 5-14(a). Typical wing tip pylon.

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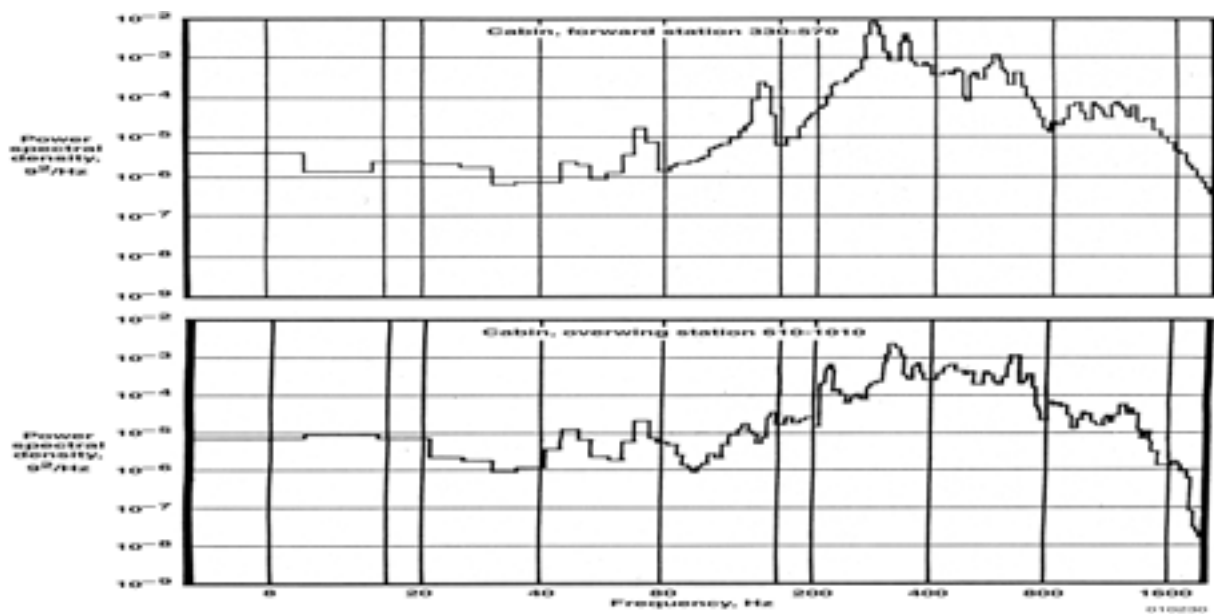
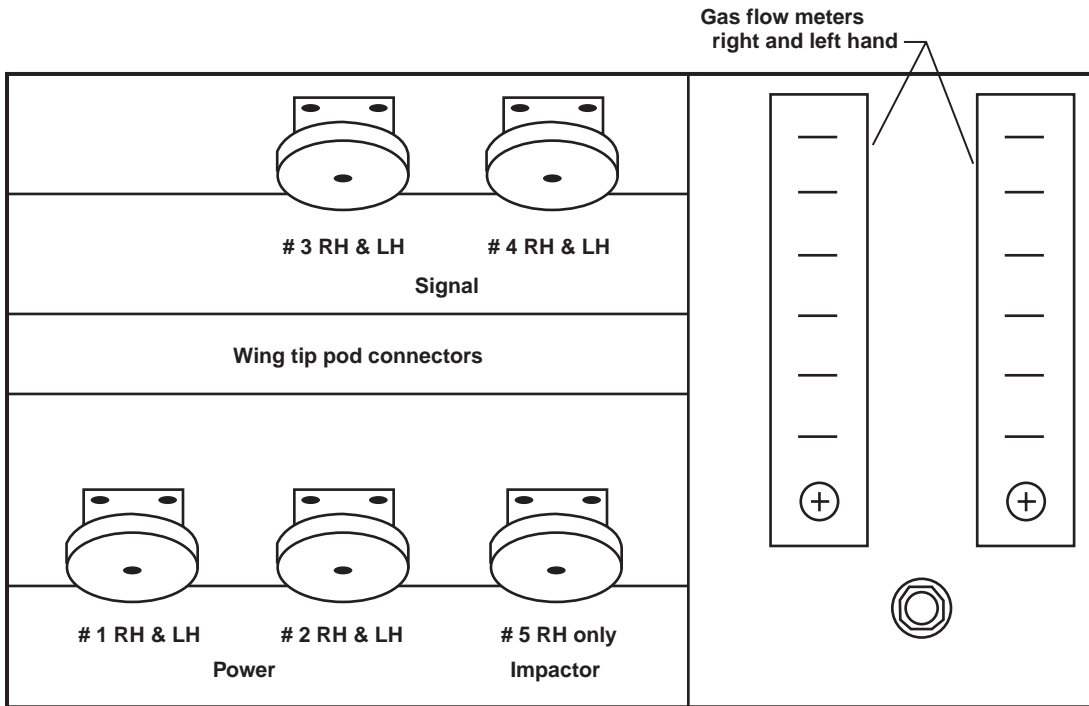


Figure 5-14(b). Typical wing tip pylon.

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Wing tip pylon connector panel
in main cabin – station 670

Cable function	Number of cables		Conductors each cable	Wire size	Max current amp	Resistance ohm	Mating connectors	
	Left hand	Right hand					Pylon end part no.	Cabin end part no.
Power	2	2	1 each twisted pair, shielded	12	20	0.19	MS24266R18-B8P	MS24266R18-B8S
			1 each twisted quad, shielded	14	15	0.30	or	or
			1 each single, unshielded	14	15	0.30	M83723/75R18-8PN	M83723/75R18-8SN
Signal	2	2	13 each twisted pair, shielded	22	5	1.60	MS3126F20-41P	MS3126F20-41S
Signal	0	1	10 each twisted triplet, shielded	22	5	1.60	MS3126F18-32P	MS3126F18-32S
Resistance is approximate for one-way. Voltage at sensor will be voltage at cabin panel. Minus the two times one-way drop.								

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Figure 5-15. Wing tip connector panel in main cabin – station 670.

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The DFRC Airborne Science Directorate has some special pallets and other supporting structures that were used in the past. These are available to experimenters who can adapt them to their use.

B. Cargo Compartments

Equipment mounted in the cargo compartments must be secured to the Brownline rails, cargo wall tie-downs, or available shelves.

C. Underwing Pylons

Certain types of equipment can be mounted under both left and right wingtips. Located there, are pylons designed for small sensors that must be far removed from fuselage air turbulence. The pylon's longitudinal centerline is parallel to the aircraft centerline and is set at zero angle-of-attack during normal flight.

Each pylon is designed to accommodate an equipment package with a maximum weight of 100 lb. See figure 5-1(a) and 5-1(b) for attachment details. Electrical power, signal, and nitrogen gas connections exist at each pylon and extend to a connector panel at station 670 on both left hand and right hand sides of the aircraft (see figure 5-15).

Experimenters desiring to utilize the wing-tip pylons should obtain approval from the DFRC Airborne Science Directorate well in advance to allow time for equipment mountings to be designed and fabricated. Flight tests may be required depending on actual equipment size, shape and weight.

All wing-mounted/pylon experimenter equipment must be grounded to the airframe. Resistance to ground checks will be performed. Equipment with greater than 1 Ohm resistance to ground will require additional grounding.

D. Exterior Locations

Equipment can be mounted on the exterior of the fuselage; however each request is considered individually. A long lead time must be allowed for the design of attachments and aerodynamic fairings that will support the gust loads and air loads encountered over the entire operating range of the aircraft.

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The design and fabrication of all external fairings is closely controlled by DFRC and, in most instances, that work is performed at DFRC. In-flight tests will be required to evaluate aircraft performance and the response of fairings to imposed air loads before the actual research flight series can begin. A safety factor of 2.25 must be used for exterior location designs, unless structural ultimate load testing has been accomplished.

8. Equipment Certification

It is the experimenters' responsibility to design and construct their research equipment in accordance with the general specifications herein. Problems should, of course, be discussed with DFRC personnel. Field measurements of the DC-8 by the experimenters are strongly recommended when new or modified installations involve tight tolerances to existing aircraft structure. If special requirements do arise, the mission manager can arrange for limited engineering design support at DFRC, provided he/she is notified well in advance.

Experimenters are required to submit detailed shop drawings of all equipment to be modified or fabricated, showing dimensions, materials, fastener types and patterns, and component weights, before initial approval for aircraft integration can be made. Stress calculations must accompany the drawings and include an analysis of the support and tie-down structure and fasteners. If the experimenter chooses not to use a standard DC-8 rack for equipment mounting, that structure must also be detailed in drawings and substantiated by analysis. The experimenter should also submit a functional block diagram of the experiment, and scaled and dimensioned layouts of equipment mounted in standard or experimenter supplied racks, with summaries of weights and moments (see sections 6 and 7). Photographs of existing equipment are very desirable.

All such data should be submitted prior to fabrication, and at least eight weeks prior to the scheduled installation of the equipment aboard the aircraft. The mission manager may specify a longer lead time in cases of complex installations.

This material will be evaluated at DFRC, and changes will be requested as necessary. Final approval should be obtained from DFRC, prior to shipping the equipment. The actual equipment construction, weight, center-of-mass, and resultant loading, are all verified at DFRC before final approval for installation is given. Experimenters should allow time for this verification when planning installation schedules.

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9. Hazardous Equipment and Materials Certification

WARNING: Listed below are equipment and processes potentially hazardous to either personnel and/or equipment. Please read the following carefully.

The operation of any potentially hazardous equipment, or use of hazardous materials at DFRC, must be reviewed and approved by the appropriate DFRC safety personnel. This applies to the shipping, operational use, and disposal of all hazardous materials, including the operation of hazardous equipment in the Experiment Integration Facility, or on the aircraft, either in flight or on the ground. Sufficient lead-time must be allowed for the necessary reviews and obtaining the proper authorization. Depending upon the specifics of the experiment, this process can take as long as several months. To help identify potential hazards, which may require DFRC approval, the following equipment categorization is used.

A. Lasers

The use of lasers at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-024, "Non-Ionizing Radiation Safety." This document must be reviewed and understood by those contemplating the installation of laser systems or the use of instruments containing lasers. Contact the mission manager for a current copy.

B. Radio Frequency and Microwave Emitters

The use of radio frequency (RF) and microwave emitters at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-024, "Non-Ionizing Radiation Safety" and by Dryden Policy Directive DPD-2570.1, "Radio Frequency (RF) Spectrum Management." These documents must be reviewed and understood by those contemplating the installation of radio frequency or microwave emitters. Contact the mission manager for current copies.

Experimenters should engineer their equipment to prevent direct and spurious radiation from interfering with the aircraft avionics equipment, which may cover the frequency range of 10 kHz - 10 GHz or more (see chapter 2).

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C. Cryogenics

Use of cryogenic liquids at DFRC is controlled by Dryden Centerwide Procedure DCP-S-039, "Cryogen Safety". Contact the mission manager for a current copy. Additional guidelines are contained in appendix B of this handbook. Cryogen usage is reviewed with respect to physiological, fire, explosion or other possible hazards associated with the use and/or transport aboard the aircraft. Type, volume, storage, and usage data is required by DFRC for all cryogenics. Some cryogenics are prohibited from use and/or transport due to exceptional hazards. These cryogenic liquids include:

- Oxygen
- Methane
- Ethylene
- Ethane
- Hydrogen

D. Compressed Gases

Use of compressed gases at DFRC is controlled by Dryden Centerwide Procedure DCP-S-030, "Pressure Vessels and Pressurized Systems". Contact the mission manager for a current copy. All compressed gases are reviewed, like cryogenics, with respect to physiological, fire, explosion or other possible hazards associated with their use and/or transport aboard the aircraft. If the particular gas is in the extremely hazardous category, or is used in sufficient quantity to be otherwise considered a high-risk item, special design and risk mitigation practices will be required.

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E. Hazardous Materials

Hazardous material is defined as anything with a flashpoint below 140 °F or with a threshold limit value (TLV) below 500 ppm, below 500 mg/m³ for fumes, below 10 mg/m³ for dust, or with a single oral dose (if liquid) at 50 percent lethality below 500 mg/kg. Each installation is reviewed for potentially hazardous materials. A complete account must be made of all gases, and dry or liquid chemicals, toxic or otherwise. This includes all cleaning solvents, refrigerants and coolants, and instrument additives, such as butanol and laser dye. The use of toxic gases in the aircraft, during flight or ground operations, is of particular concern. Data on the instrument design, installation, and proposed use of the gases will be evaluated to determine the hazard level. Where it is determined that the use and/or transport of a gas presents an unacceptable risk, containment of that gas in a secondary containment vessel may be required.

Generally, secondary containment is required when full release and mixture of the gas into a 4 ft bubble (33.5 ft³) results in a concentration exceeding 50 percent of the amount known to be immediately dangerous to life and health (IDLH). Handling of hazardous materials at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-038, "Hazard Communication and Material Safety Data Sheet (MSDS) Instruction Guide and Dictionary." Also see DCP-S-029, "Laboratory Safety." Contact the mission manager for current copies of both documents.

F. Batteries

While the proper use of small commercial grade batteries (such as AA, AAA, C, and D size Alkaline or Ni-Cd units) is normally acceptable for use on the DC-8, the use of large numbers of batteries or large capacity batteries, particularly lithium based, may present a significant hazard and therefore require DFRC review and approval. Special approval and operating procedures are required to allow unattended operation of any battery-powered equipment aboard the aircraft. See chapter 6 for additional detail and requirements regarding batteries and uninterruptible power systems (UPS).

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G. Pressure Vessels/Systems

High pressure and vacuum systems (including research dewars) are reviewed to assess the hazards associated with failures. Use of these systems at DFRC is controlled by Dryden Centerwide Procedure DCP-S-030, "Pressure Vessels and Pressurized Systems." Contact the mission manager for a current copy.

H. Motors/Pumps

All electrical motors (except the very small fan units found in most commercial electronic equipment) and motor assemblies are reviewed for electrical safety and sparking potential (see chapter 6, section 8, for motor specifications).

I. Heaters

All heater assemblies are reviewed for electrical safety, proper circuit protection devices and the presence of high temperature exposed surfaces that might serve as ignition points for flammable gases, or hot surfaces that may cause burns to personnel. Exposed surfaces, which are above 130 °F, are generally considered safety problems and must have adequate shielding and caution signs (see chapter 6, section 9, for additional heater requirements).

J. Power Distribution Equipment

Power distribution equipment and large power conversion equipment require special DFRC approval. All non-DFRC ac power distribution boxes require inspection and approval for electrical safety. They should have hospital grade duplex outlets and an approved three-wire (grounded) power cord.

K. Radioactive Materials

The use and/or transport of radioisotopes and/or radiation generating equipment involving the NASA DC-8 is controlled by Dryden Centerwide Procedure DCP-S-023, "Ionizing Radiation Safety." This document must be reviewed and understood by those contemplating the installation or transport of such systems containing radioactive materials. Contact the mission manager for a current copy.

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L. Other Hazards

Each installation is reviewed for potentially hazardous ground or airborne operations. Use of PVC jacketed wire (except within commercial units) and cable or plumbing is not acceptable. Teflon based insulating materials should be used. The use of high power equipment, moving equipment, and/or optical windows will be reviewed. Also, the requirement to change gas cylinders in flight, purging and filling of highly flammable and/or toxic substances in an instrument, or other such items may be evaluated as high risk and require some level of risk mitigation.

For potential hazards external to the aircraft (such as laser beam, radio frequency, and microwave emissions), special approval may also be required from outside agencies, such as the military, FAA, state and local government agencies, and/or agencies in foreign countries. This approval sequence can take several months and should begin well in advance of the proposed equipment installation date (a minimum four months lead-time is recommended).

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**CHAPTER 6
ELECTRICAL POWER**

1. General Information

Aircraft electrical power is controlled and supplied to the experimenters by the mission director at his/her station (see figure 3-5). Outlet stations are spaced along both walls of the main cabin and in the cargo areas (see figure 3-1). The following two types of power are available:

- The 400 Hz ($\pm 1\%$), 115 volt ($\pm 1\%$), single-phase AC power, of which a nominal 40 kVA total is available.
- The 60 Hz ($\pm 0.1\%$), 115 volt ($\pm 1\%$), single-phase AC power, of which a nominal 40 kVA total is available.
- Limited 220 volt capability.

For 28 volt DC, power supplies operating from 400 Hz power are available on request. The regulation of these power supplies varies according to the type supplied. For safety considerations, acid type batteries with liquid electrolyte are not permitted on board. Other types of batteries can be used; however, they must be approved in advance by DFRC (see section 4). Recharging in flight is not permitted.

2. Power Sources and Frequency Converters

The basic power source within the aircraft, from the engine-powered generators, is 115/200 volt, three-phase, 400 Hz AC. The four engine generators are normally paralleled by a synchronizing bus, but in special cases they can be switched to operate independently. Both 115 volt, single-phase and 115/200 volt, three-phase 400 Hz power are available to experimenters. The ground return wire of the five-wire circuitry is tied to the aircraft structure (see section 6). It is recommended that 400 Hz be used to power experiments wherever equipment permits. Good regulation, excellent waveform, and low ripple are characteristic of this system.

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Fifteen 3.5 kVA solid-state converters in the forward cargo area, in five bundles of 3 converters each, provide 115 volt, 60 Hz power for experiments. The normal configuration limits the current from each bundle to a maximum of 60 A, or 6.90 kVA per each bundle. The ground return wire of three-wire circuitry is also tied to the aircraft structure. The system has good voltage regulation, excellent frequency stability, excellent transient regulation, and good waveform relative to commercial standards.

These solid-state converters have transient overload capacity up to 175 percent (10 sec) rated load for starting motors. This accommodates the use of devices with large inrush currents. However, vacuum pump motors, for example, should be limited to 1/2 hp (375 W) when possible.

Larger size motors require advance notice and special handling to avoid power outages. Experimenters must consult with the mission manager when motor loads are planned for 60 Hz power.

Normally, the central data system (ICATS) has priority power from one of the converter bundles; so less than full power is available to the experimenters.

NOTE: The 60 Hz system is not stable enough for precise timing requirements. Accurate time signals are available from the onboard timing system.

Equipment is not available to supply 50 Hz power on the aircraft. The experimenter needing this frequency in a critical application must provide the capacity. DFRC can provide a limited amount of 28-VDC power to drive a 50 Hz converter, if arrangements are made in advance.

3. Experimenters' Power Stations

Power outlet boxes (stations) are located along both walls of the main cabin (approximately 5 ft above the floor) and in both of the cargo areas (see figure 3-1). Each station is controlled locally by switch/circuit breakers (figure 6-1), with primary control from the mission director's distribution panels. A maximum of 20 amps of 60 Hz power and 20 amps per phase of 400 Hz power is available at any one station.

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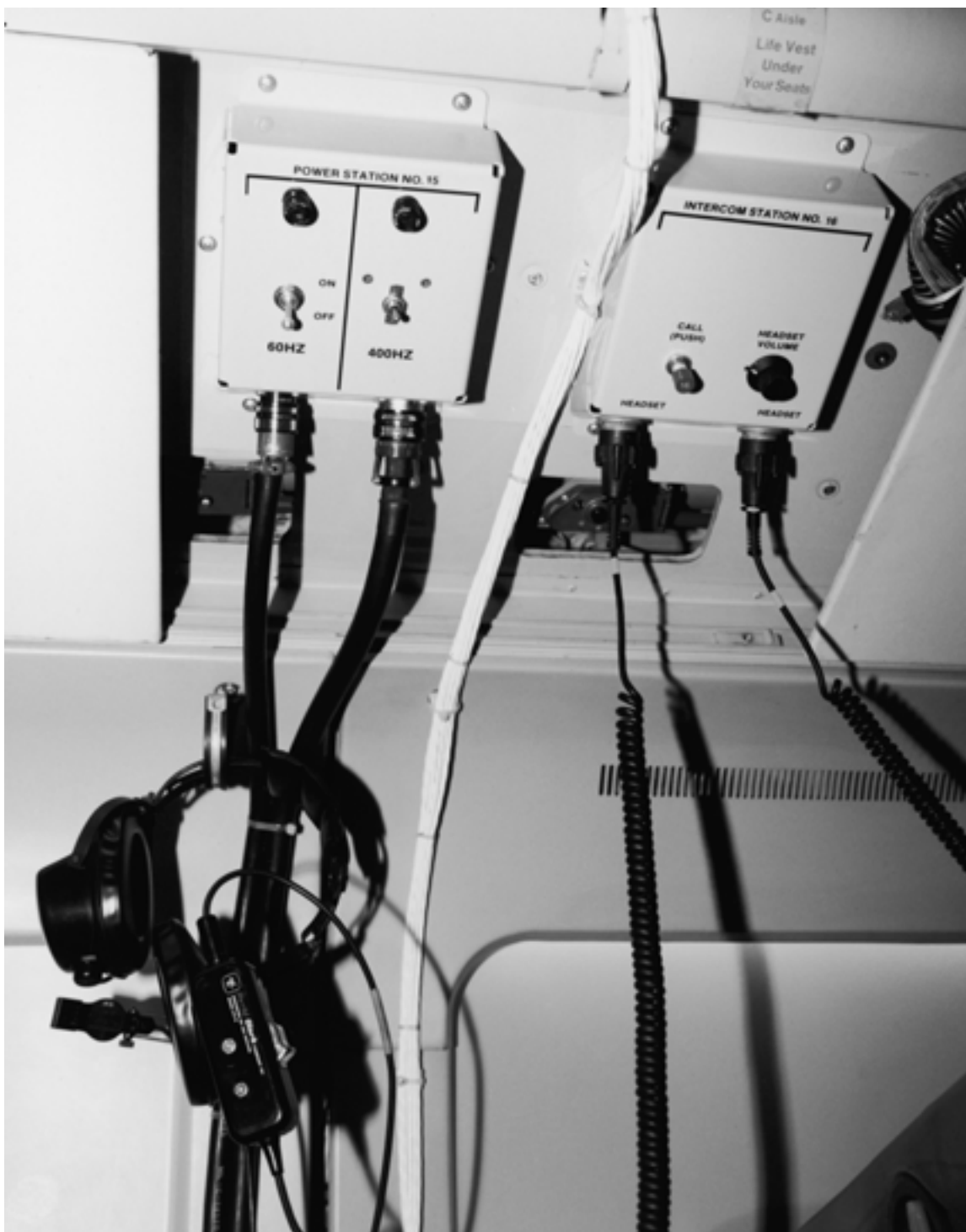


Figure 6-1. Typical power and intercom station in cabin.

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Power is connected from cabin wall stations to the experiment by DFRC-supplied cables that terminate in standard rack-mounted panels, 5 1/4 in. high, containing hospital-grade grounded receptacles. On the 60 Hz panels the receptacles are color-coded white and will accept a standard three-prong grounded plug (NEMA 5-15P or 5-20P). On the 400 Hz panels the receptacles are color coded brown and will accept a three prong grounded plug (NEMA 6-20P). Standard plugs for 60 and 400 Hz are not interchangeable, as shown in figure 6-2(a) and (b). Two-wire power leads and/or plugs are not allowed; adapters (from U.S. to European plugs) also cannot be used.

Rack panels are mounted with grounding prongs at the top. Additionally, there are special rack panels for 400 Hz, 200 volt, three-phase loads that require an eight-pin plug (MS24266R18B-8PN); DFRC can supply these on request. Rack panels are arranged as follows (see figure 6-2):

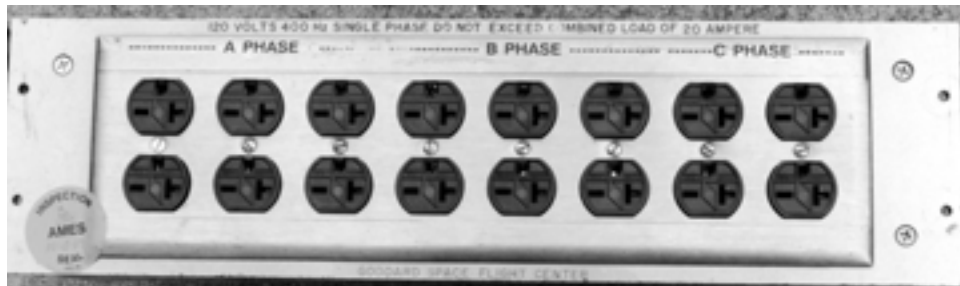
- A. For 60 Hz power, the white-colored receptacles can accommodate sixteen plugs, with a total load of 20 amps. The panel is provided with a single ground fault interrupter (GFI), which will trip off the entire panel for a ground leakage current of 5 mA.
- B. For 60 Hz power, a Pulizzi Engineering Inc. model TPC 12F-A2 power distribution panel is available as a supplement to the standard 60 Hz power panel or can be used standing alone. It can accommodate twelve plugs, with a total load of 20 amps and has EMI/RFI filtering and multi-stage spike and surge suppression.
- C. For 400 Hz power, the brown-colored, single-phase, 115 volt receptacles can accommodate sixteen plugs, with a total load of 20 amps per phase. All three phases are brought out to this panel with either four or six receptacles per phase. The mission director will control the phase use to keep the overall load as well balanced as possible.
- D. A special 400 Hz panel, also with brown colored receptacles, can accommodate two plugs for each of the three phases, and four MS plugs for 200 volt, three-phase loads. The total panel load is 20 amps per phase. A composite power panel is used in the cargo areas. Six 60 Hz plugs can handle a total load of 20 amps; two have GFI protection. Four 400 Hz 115 volt plugs (all on one phase) are limited to a total of 20 amps. One 200 volt, three-phase MS plug can provide a maximum of 20 amps per phase, provided that the 115 volt single-phase receptacles are not in use. Experimenter supplied

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power distribution equipment, such as outlet strips, which incorporate transient surge and noise suppressors, require special DFRC approval. Their use is limited to applications where they are plugged into the normal rack mounted DFRC power distribution boxes, or other approved aircraft duplex power outlets. Modifying or bypassing the grounding pin is not permitted.



1 of 3. 60 Hz



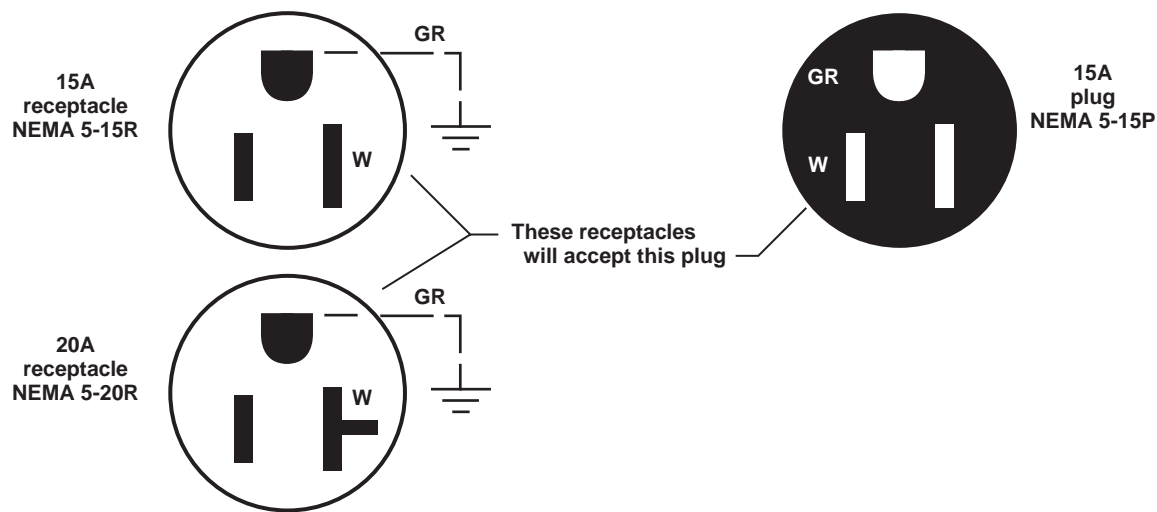
2 of 3. 400 Hz, single-phase.



3 of 3. 400 Hz, three-phase.

Figure 6-2(a). Typical rack power panel.

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Note: All power cords for use with 400 Hz must be equipped with NEMA 6-20P plugs

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Figure 6-2(b). Rack power panel receptacles.

4. Batteries

Small numbers of AA or D type alkaline or “button” Ni-Cd batteries can be used without special approval. All other battery usage on the aircraft requires approval of DFRC. Unless application absolutely requires otherwise, select benign battery chemistries with hermetically sealed cell designs from the following:

- Alkaline (Zn/MnO₂)
- Silver-Zinc
- Nickel Cadmium
- Sealed Lead Acid (“starved electrolyte” or “immobilized electrolyte” type)

The overall experiment design must consider battery assembly, shipment to the field, storage, packaging safety, shipping restrictions, shelf life limitations, and final disposal (some types require treatment as hazardous waste). Specific design guidelines are as follows:

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- A. Use smallest size (minimum capacity) battery suitable for intended application, thus minimizing stored energy and electrolyte quantity.
- B. Battery installations must withstand normal aircraft structural loads, and safely contain battery failure modes. Typical failure modes include cell rupture or explosion and cell overheating.
- C. All batteries must be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. Additionally, all liquid electrolyte batteries must be within sealed secondary containment and vented to the exterior of the aircraft to prevent toxic, corrosive, or oxidizing gases or fumes from entering the cabin. Sealed lead acid (SLA) batteries, for example, are exempt from sealed containment and venting; however, they must be mounted on a drip tray or in a housing sufficiently constructed to prevent leakage from escaping.
- D. Use a fuse or circuit breaker as close to the battery pack as possible.
- E. Minimize hazards due to cell failure through use of isolation and/or bypass diodes, thermal cutout switches, electrolyte resistant wire insulation, etc.
- F. Label battery housings with applicable safety warnings (such as corrosive/caustic liquid, flammable gas, high voltage or current capability).
- G. Unattended battery charging on the aircraft is not allowed. Battery must be isolated when not in use.

Battery approval is dependent upon the total aircraft mission configuration and assessed risk level for all potentially hazardous items on board. Approval will be for a particular mission series. Complete vendor battery specification and material safety data sheets must be submitted along with application information for DFRC review and approval action. Special approval will be required to allow unattended or overnight operation of battery-powered equipment in the aircraft.

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5. Uninterruptible Power Systems (UPS)

The structural integrity and circuitry guidelines in chapter 4 apply to UPS batteries. All units will be subjected to safety inspection and battery assembly procedures. The following specific requirements will be inspected:

- A. A front panel mounted switch or circuit breaker must provide complete battery isolation from UPS circuitry. It must be easily accessible and clearly marked "Battery Isolation."
- B. A Material Safety Data Sheet (MSDS) must be supplied for the battery.
- C. The battery must be a sealed lead acid (SLA) type, or other DFRC approved type, with immobilized electrolyte.
- D. All batteries must be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. This is accomplished by mounting the battery or UPS on a drip tray or insuring that the battery housing, or UPS, is sufficiently constructed to prevent leakage from escaping.
- E. The battery assembly must be as supplied by the vendor and must have been installed by the vendor, or other qualified personnel. If the experimenter designs the battery assembly, it must be new (within 90 days) and installed at DFRC with an aircraft inspector witness. If the battery is of the type that requires periodic maintenance, adequate documentation must be presented that traces the last battery installation date and subsequent UPS use and maintenance history.
- F. If the battery was installed before arrival at DFRC, the unit will be subject to a "covers removed" inspection for general workmanship and compliance with wiring requirements, containment, and isolation systems.
- G. Along with an MSDS for the battery, a copy of the owner's manual for the UPS must be provided. Provide circuit schematics, if available.

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6. Aircraft Ground System (AGS)

The 400 Hz bus (in the forward cargo bay), and the 60 Hz bus (behind the mission director console), are grounded by being electrically strapped to the aircraft structure. All ground connections in experiment equipment must be made to the third wire of a 115-volt plug, or the fifth wire of a 400 Hz three-phase plug. These ground conductors then return to their own bus. All power neutral leads from 400-Hz or 60-Hz loads must be returned to the power system; they cannot be grounded.

Receptacle panels are also grounded at the receptacle and serve in turn to ground the individual racks. To assure good electrical contact between panel and racks, the contacting surfaces should be cleaned with a bond brush.

As previously stated, "...the GFI units are provided on both power systems". The 60-Hz power panels have a GFI unit incorporated into each panel. A ground current in excess of 5 mA will trip the panel's GFI, causing power disconnect from all receptacles on that panel. Experiment equipment with internal power grounds, resulting in ground currents exceeding the above, will activate the GFI to disconnect power. Should it be impractical to eliminate such internal power grounds, it may be necessary to supply an isolation transformer between the equipment and aircraft power.

7. Electromagnetic Interference (EMI)

The power grounding system described above minimizes the possibility of generating ground loops within the aircraft structure. Also, every effort is made, in ground testing before flights, to assure that there is no interference between experiments because of their electrical power characteristics. However, occasionally such interference may show up in flight. In such circumstances it may become necessary to rearrange power distribution to eliminate mutual interference. It is incumbent upon the experimenters to assure that their experiment equipment is not adversely affected by any minor voltage transients, and also to assure that operation of their equipment does not adversely affect the other experiments.

Experimenters are cautioned that transmitters on the aircraft may cause interference with their equipment. Refer to table 2-1 for a list of frequencies to be considered in experiment design. Conversely, experiment equipment must not interfere with aircraft receivers; outputs should be limited to 100 me. Other factors relative to EMI and/or experiments follow:

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- A. Power leads along both sides of the cabin are in close proximity to signal leads. Some physical separation can be arranged at installation, but shielding should be considered for critical cases.
- B. EMI measurements have shown that aircraft power is contaminated with broadband RF.
- C. High-impedance detector circuits are often subject to EMI, (unshielded detector leads may pick up noise from radio frequency fields within the aircraft).

8. Electrical Safety

Electrical safety procedures are governed by Dryden Centerwide Procedure DCP-S-025, "Lockout/Tagout"; and DCP-S-026, "Electrical Safety." These documents must be reviewed and understood by experimenters who bring their equipment to DFRC. Contact the mission manager for a current copy. Safe installation and operation of electrical equipment depends on observance of the following design considerations.

A. High Voltage Protection

Reduced atmospheric pressure increases the possibility of corona discharge and arcing between high voltage components and ground. High voltage leads should be sufficiently insulated to prevent flashover. Normal cabin pressure is equal to 7,500 ft (2.29 km), and break down distance, for a given voltage, is one-third greater than at sea level pressure. For equipment in pressure canisters that are open to the outside at 40,000 ft (12.2 km) altitude, the equivalent distance is greater by a factor of 3.5.

These conditions should guide equipment design with respect to lead separation, insulating high voltage components, avoiding sharp bends, solder peaks, and other rational practices. High voltage components and cables must be clearly marked and, where practical, electrical and mechanical interlocks should also be used. Contacts on terminals carrying fifty volts or more to the ground must have guards to prevent accidental contact by personnel.

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B. Wire and Cable Insulating Materials

Polyvinyl Chloride (PVC) is a thermoplastic material composed of polymers of vinyl chloride. It is widely used for primary insulation or jacketing on a variety of wire and cable types. However, as attractive as it is as an insulating medium, it does possess properties that make it hazardous for use in an airborne environment. When exposed to high temperatures, it has the unfortunate property of out-gassing noxious/toxic products as well as heavy black smoke. For these reasons, wire and/or cable using PVC as the primary insulating material or jacket is not considered airworthy.

Electrical wire and cable used by experimenters, external to commercial manufactured components, should be clad with non-flammable or self-extinguishing insulation, with at least 150 °C rated outer insulation material. Some commonly encountered materials and their usability are listed in table 6-1.

NOTE: MIL-W-22759/11 or /16 wire is always acceptable.

Questions about material usage and acceptability should be directed to DFRC. Large volume and extended use of non-self-extinguishing insulation, in experiments to be flown on DFRC research aircraft will not be approved by the aircraft inspectors at time of installation.

Accessories such as identification sleeves, cable ties, chafe guards (spiral wrap), and cable clamps, should be of similar material. To avoid the time and cost of on-site cable replacement, suitable materials should be utilized to the fullest extent possible when assembling new components and their interconnecting cable assemblies. For those portions of experiments that have flown before, with cable assemblies that fail the above criteria, it is often acceptable to use a flame resistant outer sleeve.

Power cords that are attached to commercially procured equipment should also have other than PVC jackets. UL Type SO (neoprene jacketed, 600 volt / 90 °C) is recommended, is readily available, and is usually accepted for this application despite a lower temperature rating. Exceptions to this guideline may require special treatment.

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Table 6-1. Commonly encountered wire/cable insulation materials.

Fluorocarbons	Max. Operating Temp °C (nominal)
□ Teflon TFE (tetrafluorethylene)	+260
○ Teflon PFA (perfluoroalkoxy)	+250
○ Teflon FEP (fluorinated ethylene propylene)	+200
○ Teflon PTFE (polytetrafluorethylene)	+150
○ Tefzel EFTE (ethelene & tetrafluorethylene)	+150
○ Halar ECTFE (ethylene & monochlorotrifluorethylene)	+150
○ Kynar PVDF (homopolymer of vinylidene fluoride)	+135
○ Silicon, Rubber (Good low-temperature flexibility at -90 °C)	+200
○ Polysulfone	+130
○ Hypalon CSPE (chlorosulfonated polyethylene)	+90
○ Neoprene (polychloroprene)	+90
○ Natural Rubber (NR isoprene)	+70
■ Kapton (polymide resin)	+200
● Polyester	+150
● Nylon (polymide polymer)	+105
● Polyvinyl Chloride (PVC)	+80 to +105
● Polyethylene (PE)	+80 to +105
● Polypropylene	+90
● Polyurethane	+80

□ = TFE is recommended as the preferred wire insulation for general use in DFRC aircraft. Proper installation procedures are credited with avoidance of problems, related to cut-through resistance and cold-flow properties. Some MIL-W-81044, MIL-W-81381, and MIL-W-16878 wire is acceptable in certain applications, but DFRC approval should be obtained prior to final product specification to ensure proper airworthiness standards are met.

○ = Acceptable Materials.

■ = Kapton insulated wire (MIL-W-81381 or equivalent) has had a number of reported incidents of short circuit arc tracking (flashover) which resulted in severe propagating destruction of wire bundles in military and aerospace hardware. The use of Kapton insulated wire should be avoided. Contact DFRC for additional guidelines and usage criteria.

● = These materials are not normally acceptable due to flammability and/or toxic pyrolysis products. Contact DFRC for additional guidelines and usage criteria.

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C. Electric Motors

The use of electric motors aboard the aircraft requires individual approval by DFRC. Preferred are 400 Hz motors, to avoid starting transients on 60 Hz converters. Larger motors (such as those used in vacuum pumps) must be protected by thermal overload devices. In addition, single-phase motors must be equipped with solid-state switches to inhibit arcing at the contacts during start-up. In the absence of arc-suppressors, motors must be spark free during operation. Motors rated explosion-proof or totally enclosed non-ventilated motors are recommended. However, many fractional horsepower AC permanent split-capacitor motors are acceptable depending upon application and location. Large DC brush type motors are generally not acceptable due to the electrical arcing at the brushes. Early consultations with DFRC will help avoid problems at installation.

9. Heaters

All heater assemblies are reviewed for electrical safety, proper circuit protection devices, and the presence of high temperature exposed surfaces that might serve as ignition points for flammable gases, or cause injury to personnel. The following must be supplied to DFRC for review:

- A. A simple electrical schematic must be provided for each heater. The schematic must show the heater, the temperature controller, any fuses or circuit breakers, the power supply, and the wire size between these components. A thermal fuse is recommended between the controller and the heater for added protection.
- B. Provide product literature for the components of the assembly (heater, controller, temperature sensor, etc.).
- C. Provide a description of the location and function of the heaters. A sketch showing the location of the heaters in relation to instruments and/or probes is most helpful.

CAUTION: Exposed surfaces above 130 °F (54 °C) are generally considered safety problems, and must have adequate shielding and caution signs.

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10. Experiment Cabling

Generally, DFRC provides all cabling to the experiment from the power outlet boxes and the central computer (ICATS); the experimenter provides matching connectors. The experimenters are responsible for the cabling between two or more racks of their own equipment. These cables must be routed off the floor to permit free access between racks. Cables that connect racks on opposite sides of the aisle, are routed overhead in metal trays; 22 ft should be allowed for the overhead run.

All cabling inside of the racks must be clamped to inhibit movement, utilizing existing holes and/or openings.

11. Equipment Certification

Experimenters are responsible for the design and assembly of electrical systems in accordance with these specifications. They are requested to submit to DFRC a power break down (such as 60 Hz, 400 Hz, single-phase, three-phase) by component, for each standard rack, and any other installations elsewhere in the cabin or cargo areas.

Additionally, information should be provided about all electric motors in the experiment, to include type, starting (inrush) current magnitude/time scale, and thermal overload protection. This information should be submitted along with all the mechanical design specifications at least eight weeks prior to installation.

DFRC will review the material, request changes as needed, and prepare a power distribution plan for all the experiments in the payload. Final verification of electrical systems will be made at DFRC, prior to approval for installation on the aircraft.